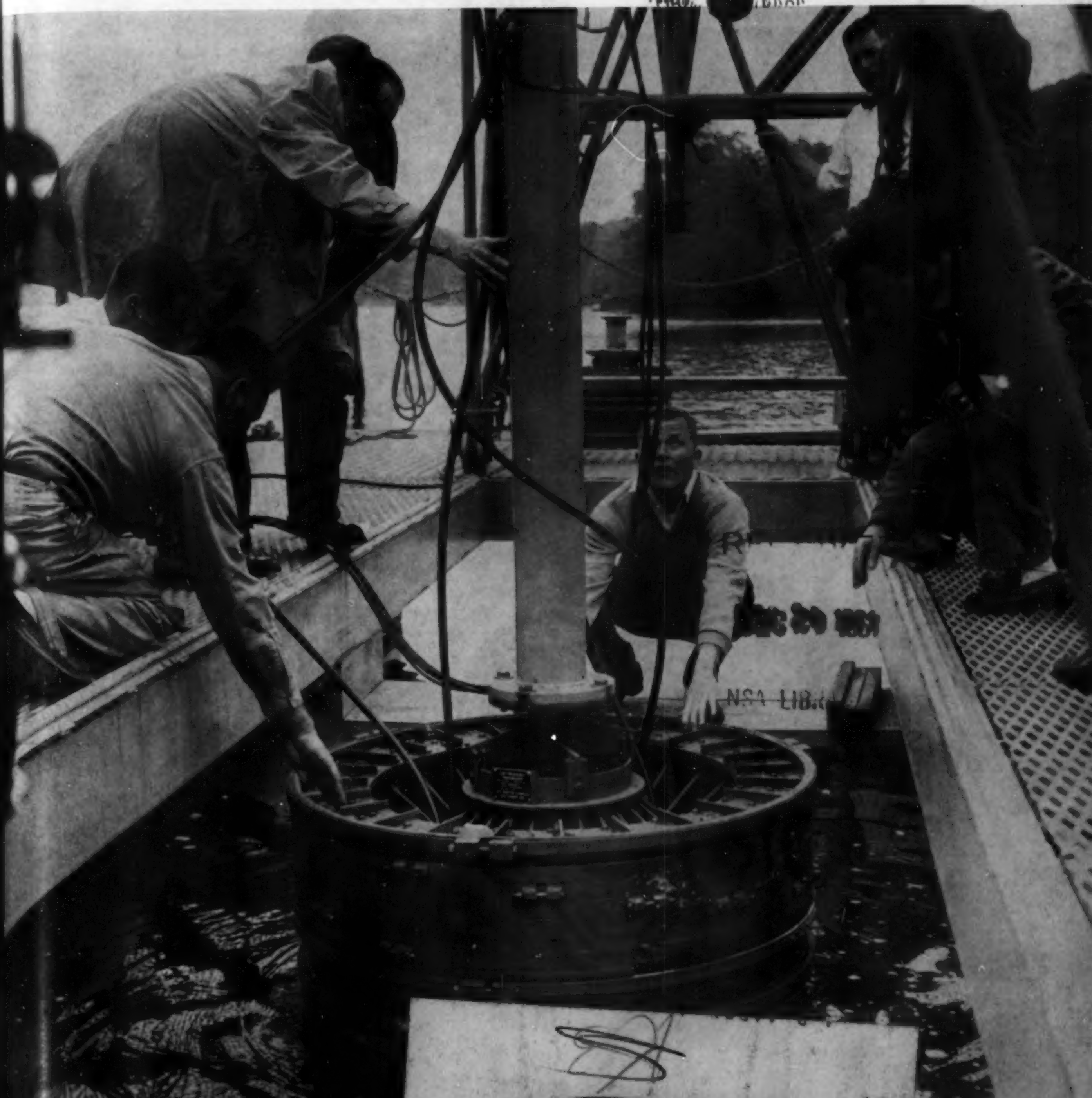
undersea technology

including underwater engineering

NOVEMBER/DECEMBER 1961
VOL. 2, NO. 6



IN THIS ISSUE: SEA FLOOR MINING

Science Serves Defense at Westinghouse

The new underwater acoustic test laboratory pictured below will be in operation this year in Baltimore, helping Westinghouse engineers solve problems in oceanographic and ASW research.

Built by the Westinghouse Ordnance Department, the new laboratory is one of the largest and best-equipped privately-owned facilities of its kind. It is 205 feet long and 175 feet wide. The air-conditioned instrument house floats on a 3½ million gallon lake, 25 feet deep and with an anechoic lining.

The laboratory will advance the development of a wide range of Westinghouse underwater acoustic equipment. Included are transducers, detection systems, weapon homing and guidance systems, and high and low frequency sonar devices.

Underwater acoustic systems built by Westinghouse are a part of various Navy weapon systems. This new acoustic laboratory at Baltimore will bring continued contributions to this vital area of American strength.

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Westinghouse

UNDERWATER ACOUSTIC LABORATORY...in our own backyard

undersea technology

COVER: As part of a deep ocean research program, Martin Electronic Systems and Products Division, Baltimore, is building this low frequency sound source to be placed on the ocean floor to study acoustic properties of the ocean. The sound source is designed for long life, with redundant units using barium titanate ceramic elements. Martin is participating in programs concerned with submarine navigation and ocean-wide ASW surveillance.

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BPA

EDITORIAL

NEWS

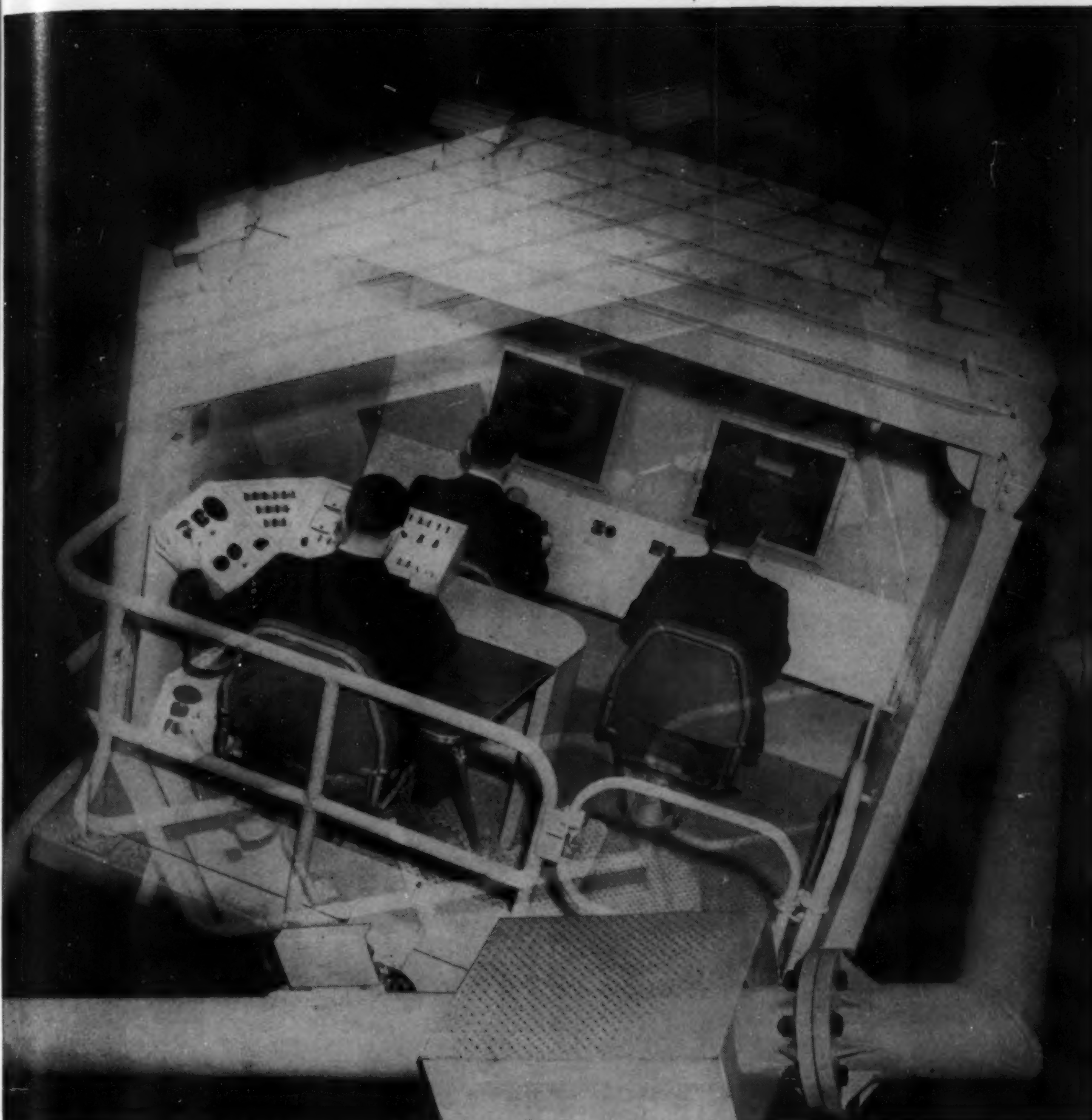
SPECIAL REPORTS

FEATURES

COLUMNS

DEPARTMENTS

PICTURE CREDITS
p. 16, Official Photographs, U.S. Navy; p. 18, Charles H. Turner & Ward Gillilan, California Dept. of Fish & Game; pp. 22-25, Scripps Institution of Oceanography; pp. 36-39, U.S. Navy.



editorial:

DO WE NEED OIA?

Lately, we have encountered repeated pleas for the establishment of a central, independent, national organization—a sort of Oceanic Industries Association—which would assimilate, collate, and formulate the many needs, views and objectives of this effort into clear-cut areas of common interest for the guidance of government and the benefit of science and industry.

Now, when Congress requests guidance it usually gets as many different viewpoints as there are witnesses. Further, Federal Communications Commission has yet to assign a frequency band for the exclusive use of oceanography, which, after all, is the science of our technology. As a result, programs requiring the telemetering of vital data encounter all sorts of problems—not the least of which is possible interference with or by some nearby missile range. This is a problem that's going to get worse before it gets better unless action is taken promptly (see *Oceanic Telemetry*, p. 40). Yet no one is making the proper effort to win FCC action.

And standardization: The oceanographer buys his cable by the foot; his winch reads off in meters; and his instrumentation measures in fathoms. Plugs, voltages, etc., of one research group's instrumentation are incompatible with equipment on another group's ships. There is much room for improvement and much to be gained by industry-wide agreement on certain operating standards and procedures.

What is proposed is not *another* technical society with all-too-frequent costly and time-consuming meetings, but rather a central clearing and coordinating effort dedicated to the orderly progress of the industry. In a word, the OIA would be to the field of undersea technology what the Aerospace Industries Association is to aircraft, missiles, and spacecraft. It would not only represent the industry as a whole before the various branches of government and the public but would also feed back studies to industry for use in future planning.

We do not propose ourselves to establish such a group, but if the need and desire are confirmed, we will lend it our editorial support and provide whatever starting services we can. We are writing this editorial to ask for your pro's and con's on this matter—if you feel the need for such an organization and if, feeling the need, you would be willing to support it. This could be of critical importance to your industry. Take the time to think about it and write us your views.

Seabrook Hill

NEW EDITORS

KOCZY

GAUL

MERO

Again, we are pleased to announce the addition of three new members to our editorial staff—Dr. Friedrich "Fritz" Koczy, *Oceanography;* Mr. Roy D. Gaul, *Oceanography;* and Dr. John L. Mero, *Ocean Resources.*

Dr. Koczy, a member of the staff of the Institute of Marine Science at the University of Miami since 1957, serves as a full professor and Chairman of the Division of Physical Sciences.

An Austrian by birth, Dr. Koczy moved to Sweden, just prior to the outbreak of World War II, where he worked under Professor Hans Petersson at the Oceanographic Institute and also at the Swedish Board of Fisheries in the Oceanographic Division. He participated as an Oceanographer during the Swedish Deep-Sea Expedition of the *Albatross* in 1947-48.

While in Sweden, he was the counsellor to the Joint Commission on Oceanography of ICSU and Swedish expert in hydrography to the ICES.

His principal interest is oceanology and has published papers covering geochemistry, morphology, physical oceanography, sedimentology, planktology and sediment age determination.

His organizational memberships include the Committee on Oceanography of the National Academy, National Research Council; Panel member on Earth Sciences of the National Science Foundation; the Committee on Radioactivity in the Ocean of the SCOR.

Mr. Gaul is currently a research scientist in the Department of Oceanography and Meteorology at Texas A&M College. After receiving a B.S. degree in Civil Engineering and a Master's degree in Physical Oceanography he joined the staff of Marine Advisers in La Jolla, Calif. as Engineering Oceanographer, and later worked for the U.S. Navy Hydrographic Office in Washington, D.C. as Physical Oceanographer.

Mr. Gaul has authored or co-authored numerous oceanographic reports and papers on wave statistics, ocean currents, internal wave observations, telemetry systems, and engineering techniques applicable to off-shore construction.

Dr. Mero, who holds a B.S. in Mining Engineering, a Master's in Engineering Science and a Doctorate in Engineering, is a member of the Institute of Marine Resources at the University of California.

His work at the Institute is largely concerned with investigating mineral resources of the ocean and economic and technical aspects of recovering minerals from the marine environment. In connection with these studies, he has participated in a number of expeditions on ships of the Scripps Institute of Oceanography. His studies have led to essentially unlimited supplies of a number of industrially useful minerals in the ocean.

Dr. Mero has published papers in the fields of mineral economics and gamma ray and x-ray fluorescence spectrometry. He is active in the fields of oceanographic instrumentation and sea-floor photography and is presently writing a book on the mineral resources of the ocean.

MARINE EDITOR BECOMES UST CORRESPONDENT

We take great pride in welcoming Mr. Jan Hahn to our staff as *Woods Hole Correspondent.*

Mr. Hahn, editor of the Woods Hole publication OCEANUS, has been with the Woods Hole Oceanographic Institution since 1947. He has taken part in about 25 oceanographic cruises on the research vessels *Atlantis, Bear, Chain, Caryn, Crawford, Albatross III, Aries, Balanus,* and the *Cap'n Bill II.* Until 1960 he also was Public Information Officer at Woods Hole. Mr. Hahn has written many articles on oceanography, served as advisor to LIFE and other periodicals in the preparation of major publications on the ocean, prepared exhibits, and presented many lectures before groups as well as radio and TV. He served also as advisor and photographer in the preparation of the films: "Science of the Sea", and "Challenge of the Oceans." His still photographs and motion picture footage have been used widely in the popularizing of oceanography.

He has published scientific papers on bottom photography and on bottom investigations, and annually prepares oceanography reviews for several encyclopedias.

Since 1952 he has prepared a prediction of the Gulf Stream's behavior for the crossing of the yachts in the biennial Newport-Bermuda race; a service which has become more and more popular with the yachtsmen.

Mr. Hahn is a member of the American Society of Limnology and Oceanography, the National Association of Science Writers, and the Netherlands Academy League.

LETTERS

Misguided . . .

To The Editor:

I recently received a misdirected copy of "Undersea Technology" and was impressed with the material content.

It is often difficult to determine which magazine should receive the scarce reading time available. There is no such question here. This magazine will be of definite value in helping me carry out my function which is the over-all monitorship of selected projects.

F. W. Robertson
Defense Electronics Div.
General Electric Co.

Praise the folly of errors.—Ed.

We Need Help!

To The Editor:

We have recently had an inquiry about strong, flexible underwater mine mooring line. The line is supposed to be made up of glass filaments coated with a plastic material to make it flexible. The resultant fibers should not exceed ⅛ in. in diameter. The line is supposed to be capable of supporting a few thousand pounds weight and tolerating the salt water environment for long periods of time.

Can anybody out there help us?—Ed.

Kudos

To The Editor:

I note in passing that Don Groves' article "UST Needs In Review", that appeared in the July/Aug. issue of UST, has been read into the Congressional Record appendix, on Sept. 16 by the Hon. R. Walter Riehlman (R-N.Y.).

We are quite proud that Mr. Riehlman found the words of Mr. Groves, a GE System's Specialists, of value in pointing out the challenges and "unfinished business" in UST.

My heartiest congratulations, also, on your most recent Sept./Oct. issue. It fits right into the UST pattern of one very interesting and useful issue after another.

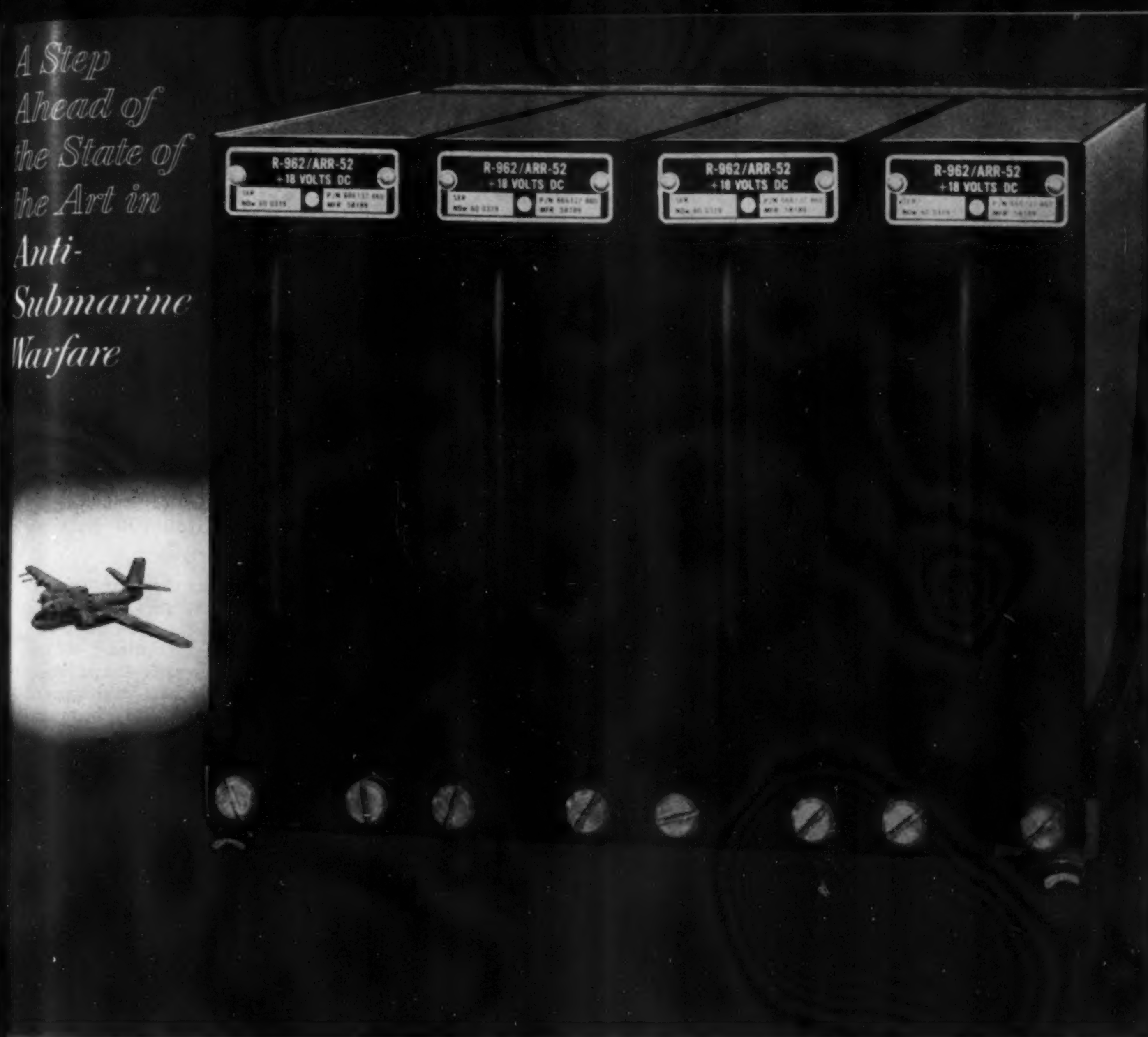
William A. Ternent
Information Services
Defense Electronics Div.
General Electric Co.

We Goofed!

In our last issue of UST (Sept./Oct.) there appeared an article titled "The Ocean" by Robert M. Snyder. It has been brought to our attention —both internally and externally— that the references were omitted . . . unintentionally, albeit. Someone once said, "Often times the excuse doth make the fault worse", so, with nothing more to say, we humbly apologize.

References:

1 Sverdrup, H. U., M. W. Johnson and R. H. Fleming, **The Oceans**, (1942), Prentice-Hall.
2 National Academy of Sciences Report No. 309, "Oceanographic Instrumentation," 1952.
3 Hydrographic Office Publication No. 9, "American Practical Navigator," U.S. Govt. Printing Office, Washington, D.C.



A Step Ahead of the State of the Art in Anti-Submarine Warfare
R-962/ARR-52
+18 VOLTS DC

capital report

E. E. Halmos, Jr.

Racking up savings for taxpayers, and greater efficiency for the service, is a little-known Navy organization: The Public Works Management Group of the Bureau of Yards and Docks. Organized in 1953, group is charged with "cranking in" best possible management techniques to Navy's huge job of maintenance and upkeep of its shore establishment.

Job is staggering, and results impressive: Navy's shore bases now aggregate more than $20 billion in value, continue to grow, and the service spends about $500 million a year on maintenance and operation. Remarkable thing is that — despite spectacular growth (from about $1 billion before World War II) and price rises, cost of maintenance hasn't gone up at all in several years, personnel operating bases has been cut more than 10,000. Savings of more than $12 million in three years on transportation equipment alone are an example of what's been done.

Saving has been accomplished by use of best business management methods, a lot of common sense: Periodic inspection of structures and machines to anticipate repair and servicing needs; good scheduling; a system of estimating costs, manpower, time and materials needs; good inspection. The 22-man Group, commanded by Capt. Harry N. Wallin of BuDocks, keeps plugging away at improvements.

Navy is pushing experimental work on two types of amphibious "vessels" for use as landing and attack craft. One (for which a contract has been let to Avco Corp.) would be an amphibious hydrofoil that could be used both as landing craft and cargo carrier for Marines; another (contract for research let by Maritime Administration to Vehicle Research Corp., Pasadena) would be a surface-effect ship, travelling on an air cushion and capable of moving at speeds of 100 mph or more. On hydrofoils, Navy has also let a contract to RCA for research on autopilot control systems.

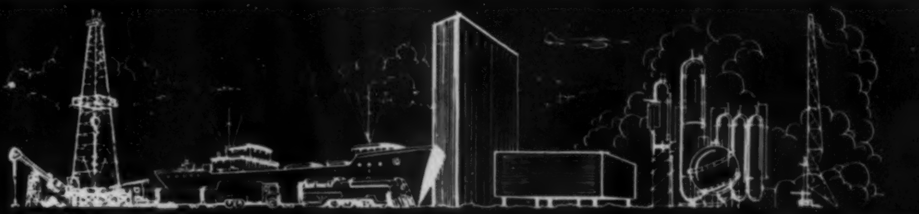
Industry is also moving heavily into the Undersea field: Lockheed Aircraft has announced that within 10 years its efforts in oceanographic areas will be as extensive as present space and missile activities; Grumman is converting its SA-16A tri-phibian Albatross plane (under Air Force contract) to a faster, longer-range craft specifically for ASW work. Aerojet General is working on a glass-enclosed submarine, and General Mills is developing a midget sub for exploration work.

Another aspect of oceanographic research — "sea-slamming" on structures — will be checked under Maritime Administration contracts by three U.S. universities. Studies (by University of California, M.I.T. and Stevens Institute of Technology) will look into structural bottom damage and hull stresses imposed by "slamming" action of waves, seakeeping qualities of ships, and ship controllability.

Navy may have a solution for placing "caches" of fuel at sea for fast-maneuvering ships, with successful conclusion of tests of a 50,000 gallon submersible rubberized nylon bag, which "inflates" (with fuel) to a size of 22 ft wide by 60 ft long by about 5 ft in diameter. It is anchored to the sea bottom by a cradle held on four heavy piles driven into the bottom and can be pumped at the rate of 1,000 gallons per minute through lines invisible to aircraft but readily available to ships. Big bag is manufactured by U.S. Rubber Co., is made in two layers of coated nylon.

U.S. has already launched its largest season of scientific research in the Antarctic, with nearly 200 scientists from some 25 universities and governmental agencies taking part in research projects on and around the Antarctic continent. National Science Foundation grants totalling $4,687,783 will pay for part of the work. Additional grants of $5,500,000 are still in NSF's till, waiting award for further study programs in this area. Biology, geology, glaciology, gravity, mapping, meteorology, oceanography, upper atmosphere physics and seismology are among subjects to be studied.

U.S. Atomic Energy Commission and Columbia University plan to place a nuclear-powered seismograph on the sea floor off Bermuda in 1962, to record earthquakes originating under the oceans, permit far more sensitive recordings since the ocean floor is one of the quietest areas of the earth's surface. A 400-pound generator, powered by radioisotopes, will be capable of delivering 5 watts of electricity to power the apparatus, and for transmitting data to buoy-mounted tape recorders on the surface.



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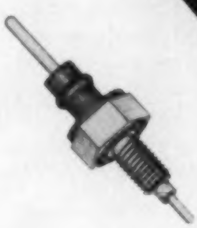

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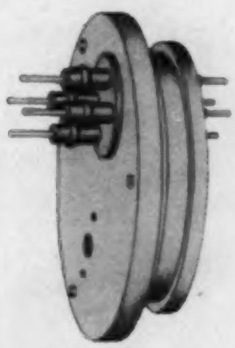

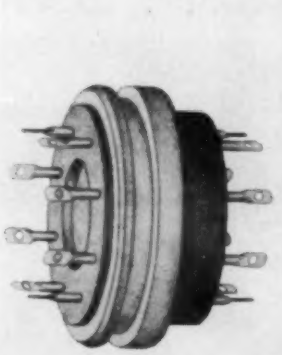

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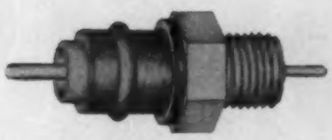

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ASW

A $1 million shore-based trainer for the Navy's ASROC anti-submarine weapons system has gone into operation at the Norfolk Navy Base. The trainer, built by the Ordnance Division of Minneapolis-Honeywell, consists of a number of consoles to locate and track enemy subs, compute their course, range and speed, aim the ASROC launcher and fire the missile.

COMMUNICATIONS/NAVIGATION

The first Navy Drone Anti-Submarine Helicopter—equipment has been delivered to Gyrodyne Co. of America, Inc. by Motorola for the Navy's DASH program. This digital communications system provides accurate, remote flight control of the DSN Drone from either shipboard or land installations.

An underwater telephone system is being delivered in production quantities to the Navy's BuShips by Gulton Industries. The rugged sonar system—consisting of a transducer, a receiver/transmitter unit and a control box—enables surface or submarine vessels to talk with one another via sound waves.

A solid state, closed circuit TV system that can "see" in the dark has been adapted for missile surveillance by the Bendix Corp. The system can be installed on aircraft or submarines for missile observation and satellite tracking.

ACOUSTICS

Acoustic instrumentation experiments are being conducted in deep water for the Naval Underwater Ordnance Station by General Motors' Defense Systems Div. Experiments, now being conducted in the Santa Barbara Channel off California, will soon be moved to the Tongue of the Ocean, an area of deeper water in the British West Indies south of Nassau.

An improved type electronic echo depth sounder will soon be outfitted on 50 vessels of the Navy's "Freedom Fleet", the Military Sea Transportation Service. The newly-designed depth sounders, developed by Raytheon Co., give shipmasters instantaneous readings of water depth on a flashing light indicator and a simultaneous continuous graph of the ocean floor for navigation.

The R/V EARL OF DESMOND, flag ship of the Geraldines' LTD. fleet of "floating laboratories", was recently in the Bahamas conducting research on "bottom bounce" theory for the Martin Co. Navy's Bureau of Ships recently awarded Martin Co. a contract for design of an advanced navigation aid for submerged submarines to be installed in AUTEC.

SUBMERSIBLES

SEAPUP VI, a two-man underseas research vehicle produced by General Mills' Eleceronics Group, can hover, rotate, and be maneuvered precisely in vertical, horizontal, and inclined planes to depths of 6000 feet. It is equipped with a specially adapted mechanical arm identical to that installed on the bathyscaph, TRIESTE.

MATERIALS

Titanium hulls may be the next step in submarine technology. The Battelle Memorial Institute has developed a welding process allowing joining of 2-in. titanium plates (previously, 5/8-in. was the thickest). The new type hulls would be as strong as steel, but weigh about one third less, permitting faster speeds and greater depths.

FACILITIES

Newly established facilities of Clevite Ordnance Div., Clevite Corp., will provide services for West Coast and Southwest Electronic Systems companies. Under the direction of H. W. Gottfried, the new office, located at 3336 East Foothill Blvd., Pasadena, Calif, will be concerned with underwater sound systems, acoustic instruments, and other underwater devices.

The ASW Division of Aerojet-General Corp. has been split into two independent units—the Oceanics Division under the direction of former ASW Div. manager Calvin A. Gongwer and the Torpedo Division

The General Mills SEAPUP VI is capable of supporting two men comfortably for an 8-12 hour period.

Jim Fitzgerald, president of the Geraldines' Ltd., checks out equipment aboard the EARL OF DESMOND.

headed by George M. McRoberts. Some of the projects now underway at the oceanics Div. are underwater remote controlled utility drones, ocean turbulence meters, silent fluid transmission valves, and underwater communications and defense systems. The Torpedo Div. is concerned with research, development, testing and production of underwater weaponry.

OCEANOGRAPHY

A mechanical "porpoise", designed to conduct Navy oceanographic studies while gliding underwater, is under construction by the Aeronautics Div. of Ling-Temco-Vought's Chance Vought Corp. One of the first proposed studies will be charting water temperatures at various depths.

The first known underwater analysis of the sea's naturally occurring radioactive sources have been made by the Navy with a new radiation measuring device a mile beneath the Caribbean Sea. Called DUNC—Deep Underwater Nuclear Counting—the device is so sensitive it can measure one atom of radium in a billion billion molecules of water.

An unmanned weather station designated NOMAD for Navy Oceanographic and Meteorological Automatic Device, is moored in the middle of the Gulf of Mexico keeping an eye out for approaching turbulent weather. Floating on a 20 x 10 foot platform, the station is designed to monitor and report weather data automatically for an area of hundreds of miles of sea. The Navy is planning on stationing seven more units in the Pacific and Atlantic Oceans where typhoons and hurricanes are most frequent.

An oceanographic measurements team for the Antarctic Research Program has been provided by Texas Instruments Inc. under a National Science Foundation contract. The team will operate and maintain a variety of equipment aboard the research vessel USNS ELTANIN.

A series of "underseas satellites" is scheduled to be strung between Hawaii and California next year in an effort to help explore the uncharted oceans. Walter Munk of the Scripps Oceanographic Institution hopes to launch the project with basketball-size "satellites", each containing a gauge to measure the tides, a seismometer, and a transmitter.

A long chain of mountains, hitherto unknown to man, has been discovered under the North Pacific Ocean by the U.S. Coast and Geodetic Survey Ship, PIONEER. The sea-mounts, 34 in all rising 3,000 to 6,000 feet and extending over a 1,000-mile area, are only the first of many new discoveries expected from "the first methodical ocean-wide survey in modern history". The ship is expected to comb 3,000,000 square miles of ocean between the Hawaiian and Aleutian Islands.

CONTRACTS AWARDED

ARMA Div. of American Bosh Arma Corp., $1.5 million from the Navy for compact antisubmarine missile systems.

Sparton Electronics, $14.5 million from the Navy for various types of Sonobuoys and ASW devices.

Telecomputing Corp., with Lockheed Missiles and Space Co. for automatically activated primary battery for in-flight power for POLARIS A3 guidance system.

Motorola, $6.3 million from the Navy for Sonobuoys.

Harris ASW Div/General Instruments Corp., $2 million from Navy for surface ship sonar transducers.

Sperry Gyroscope, $6.5 million from Bureau of Naval Weapons for submarine detection systems.

SIE Div/Dresser Electronics, $1 million from Bureau of Ships for variable depth sonar hoists.

Lockheed Aircraft Corp., $1.4 million from Navy for planning and installing a hydrophone array at sea.

Huges Aircraft Co., $5 million from Navy for POLARIS guidance systems.

Raytheon Co., $5.1 million from Navy for POLARIS R&D.

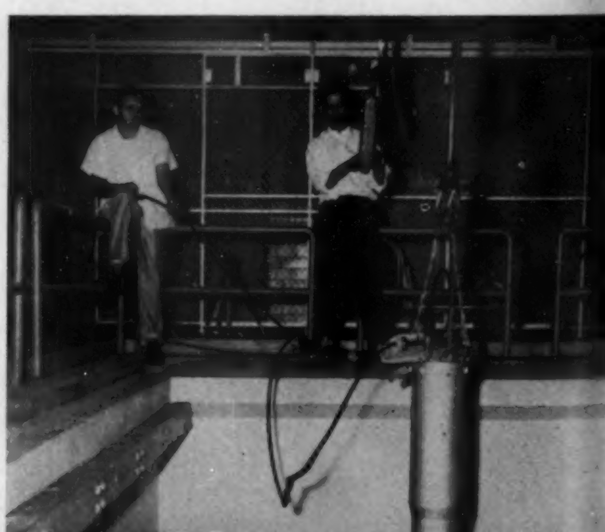
Electric Storage Battery Co., $7.5 million from Navy for submarine batteries.

Daystrom, Inc., $2 million from Navy for continued R&D on JULIE, a submarine detection program.

Bendix Corp. with Bureau of Ships for five automatic maneuvering control systems for POLARIS submarines.

Hughes Aircraft Co., $1.8 million from Bureau of Naval Weapons for an infrared device to measure small temperature changes.

NOMAD gets last checkover before starting its lonely vigilance in the Gulf of Mexico for bad weather.



Ultra-sensitive DUNC gets "dunked" into a salt water testing tank at the Naval Ordnance Laboratory.

scanning

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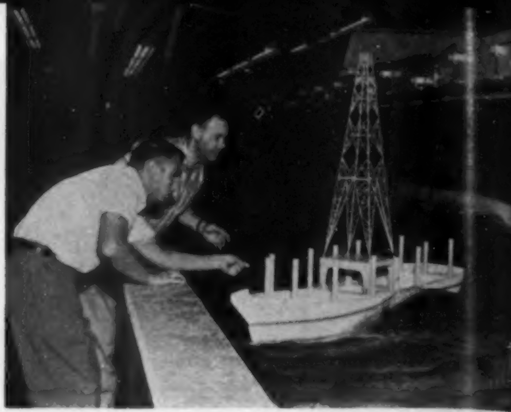
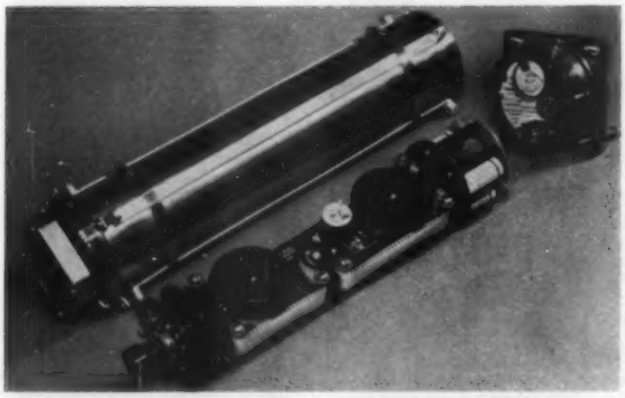
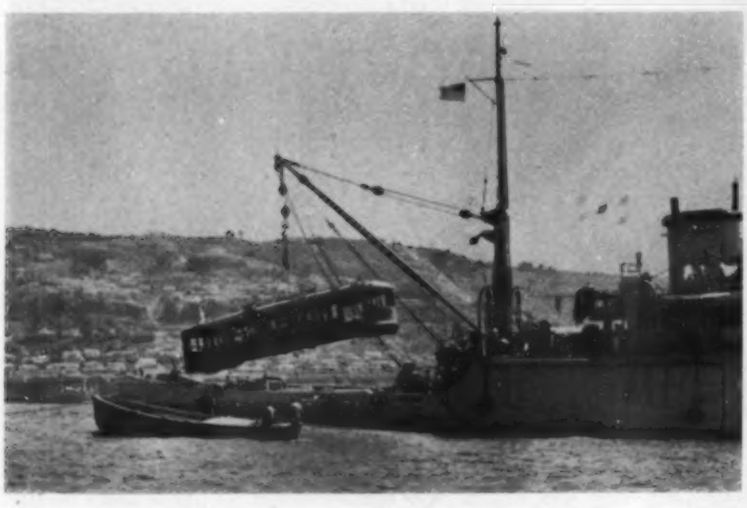


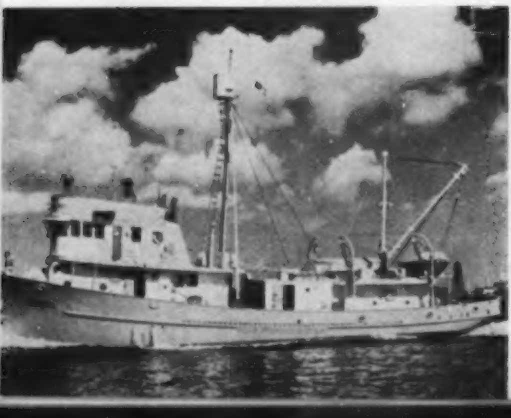
CUSS II, first vessel specifically designed for free floating offshore drilling, is under construction for Global Marine Exploration Co. at the Equitable Equipment Co. yard in New Orleans. Above, model of CUSS II undergoes tests in the wave tank at Convair. The diesel electric vessel will be able to drill in excess of 15,000 feet in any depth of water.



A deep-sea camera, built by Edgerton, Germeshausen and Grier, Inc., can probe the oceans greatest depths at pressures of 17,000 psi. Data panel at top right gives pressure, time and other information which is photographed on the film. The camera was designed especially for the French Bathyscaphe ARCHEMEDE.



Fish attracted to man-made structures populate an off-shore Humble Oil drilling rig. At left, the Navy lowers a streetcar into the ocean to form an artificial reef (as above) to lure food fish into an area that is now practically barren of fish.



California's new biological research vessel, ALASKA, (left) permits underwater viewing through 1-in. thick crystal, glass ports (right) flush mounted in the hull 4-6 feet below the water line. A unique watertight compartment inside the ship protects against flooding in case of window damage.

undersea technology

Vol. 2, No. 6
November/December 1961

TO KILL A SUBMARINE

you've got to find it

To kill a submarine, you've first of all got to find it, and therein lies the bulk of the U.S. ASW effort. By comparison the final act of destroying it is relatively simple — particularly with a nuclear warhead — though even here there is a pressing need for ASW weapons with greater effective range.

Underwater search today is primarily acoustical — both active and passive sonar — deployed by fixed wing aircraft, helicopters, surface ships, and submarines. A secondary search technique employed solely by aircraft measures the disturbance of the earth's magnetic field due to the nearby presence of a sub's metal hull. System is MAD, for Magnetic Anomaly Detection.

However, the maximum range at which an enemy submarine can be detected by any of these methods is 30-to-100 miles, depending on local conditions, assuming the submarine is making enough noise to be heard, and assuming that the target is not hiding behind a thermal discontinuity where acoustically it cannot be seen.

Thus, compared to the vast volume of the ocean, the range and discriminatory capabilities of present detection systems leave a great deal to be desired. If the sensing elements themselves lack range, then it is necessary to deploy great numbers of these sensing elements in order to be certain of covering any given area (volume) of ocean, and their deployment by multi-million dollar ships and aircraft in sufficient numbers to provide assured coverage of all the ocean areas of interest turns out to be an economic impossibility.

As it is, procurement for ASW search, detection, localization, and identification gear is rising sharply. For example, sonobuoys which, in the past have been procured at a rate approximating 50,000 a year, are now being bought at a rate of something like 200,000 a year. Procurement of the $1.5-million Grumman S2F-3 Tracker and the $6-million Lockheed P3V-1 is rising and will continue to rise. Relatively speaking, vast numbers of these aircraft and their associated equipment will be bought over the coming years. Current programming anticipates a total of 629 Tracker-type and 497 Orion-type ASW aircraft, of which 144 and 64 respectively have been ordered so far. Long range requirement for large manned ASW helicopters is 363 of the Sikorsky HSS-2 class. Including HSS-1 and HSS-1N (which HSS-2 replaces), procurement so far totals 161. The drone helicopter DASH will eventually be fitted to 300 ships at a density of two per ship. At $60,000 each, this is a $36-million initial procurement. In addition, Navy anticipates a normal peacetime attrition of up to 40 per cent a year.

In terms of ships, both surface and subsurface, the Fiscal 1962 new construction budget contains funds for seven guided missile frigates, three A-powered Thresher class submarines, 10 Polaris submarines, three escort ships, and three guided missile escort ships — all with important ASW missions. A total of 51 older Navy ships are being converted this year to modern ASW equipment.

These figures are thrown in just to provide a measure of appreciation for the economic problems in ASW. Even this high rate of procurement will not give the U.S. a 100 per cent guarantee of finding all the submarines that might threaten our security.

There are two routes to greater ASW capabilities:

- Improved performance and reduced cost of present techniques — namely acoustic. Improved performance will provide detection at greater ranges and under more adverse conditions (high sea noise, low target noise), and reduced cost will enable more systems to be deployed for the available ASW dollar.

- Development of other techniques, and herein probably lies the greatest potential for orders of magnitude improvement in capability. The so-called "unsound" areas of research that hold some promise range from an understanding of the so-called radar anomaly to coherent light transmission in sea water and earth current detection and communications. There is even serious consideration given to the possibility of forming some kind of alliance with the porpoises to do our searching for us (see Hello Navy, This Is Notty, P. 36).

The radar anomaly relates to the unpredictable phenomenon whereby surface ship radar has on occasion tracked deeply submerged submarines for extended periods of time. Research into this has all but halted due to the complete inability of anyone to come up with any leads from which to proceed.

Suspicion of the existence of discrete windows in the ocean for transmission of either radio frequency energy or coherent light persists and research contracts are in force aimed at discovering these.

In addition, with respect to earth current techniques a recent Department of Defense report states: "There is the distinct possibility that shore-to-ship and ship-to-ship underwater communications may be advanced by an order of magnitude utilizing this technique. Also, the possibility exists of locating ships and submarines which are completely submerged and protected against sonar detection. It is quite definite that large masses may be located by this technique; it only remains to determine by test the relative sensitivity of the system."

It is certain that the Russians are going all-out to develop an ironclad defense (which first of all means detection) against U.S. submarines. No one has it yet. Who gets it first may win *the* race of the century.★

SEA FLOOR MINING

By Dr. John Mero

Institute of Marine Resources
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THE FIRST CONCRETE STEPS in creating a new, and potentially great, industry were taken in August of this year when the Department of the Interior called for nominations for the leasing of submarine phosphorite deposits along the west coast of the United States. A company in the Los Angeles area, interested in mining these deposits to obtain raw materials for the manufacture of agricultural fertilizers, made the request for this action. These activities are the outgrowth of an investigation of the economic potential of sea-floor minerals initiated by the University of California less than four years ago.

In 1958, the Institute of Marine Resources of the University of California at San Diego and the Department of Mineralogy Technology of the University at Berkeley undertook a joint research to investigate the technical and economic aspects of mining various minerals found on the ocean floor. From this program have come several reports which show the technical and economic feasibility of mining certain minerals found in great abundance on the sea floor.

Minerals of Economic Interest on the Sea Floor: The marine environment can be divided into four realms in regard to sources of minerals. These are marine beaches, the continental shelves, ocean water, and the deep-sea floor. The mineral resources of each realm are varied and they are vast. Presently, our studies at the University are being concentrated on the minerals of the ocean floor, largely because it is these deposits about which we know the least. Early in our study of the various sea-floor deposits, it became evident that two types of sediments held promise of being economic to exploit within the near future. One of these materials is manganese nodules. Table 1 lists the metals of economic interest found in sea-floor manganese nodules. The gross recoverable value of metals in manganese nodules ranges from $45 to over $100 per ton of nodules at present (1961) prices and the economics of mining and processing this material look very favorable (Mero, 1959). Table 2 lists some other materials found on the ocean floor that are of economic importance.

Phosphorite: A material found in many locations, generally on the continental shelves, that is of immediate economic interest is phosphorite. It has been found off the east coast of Australia, off Japan, off Spain, on the Agulhas Bank off South Africa, along the Atlantic coast of the United States, and along the west coasts of North and South America. And, as very little deep-sea dredging has been done off the coasts of most countries bordering the sea, phosphorite can be expected to be found in many other areas of the world. This material, because of its importance in modern agriculture, has great economic significance for such countries as India, Japan, Australia, and certain African and South American nations. The annual world consumption of phosphorite is over 36 million tons and is steadily increasing.

Extensive phosphorite deposits were discovered off the coast of southern California in 1937 by scientists of the Scripps Institution of Oceanography (Dietz, et al., 1942). Since that time phosphorite has been dredged in over 125 locations from north of San Francisco to south of San Diego. The mining of these phosphorite deposits is of great importance in that not only will they provide the west coast states with a low-cost source of phosphate rock,

Table I — Partial Chemical Composition of Manganese Nodules from 54 Locations in the Pacific Ocean

Element	Weight Percentages (Dry Weight Basis) Maximum	Minimum	Average
Manganese	50.1	8.2	24.2
Iron	26.6	2.4	14.0
Cobalt	2.3	0.014	0.4
Nickel	2.0	0.16	1.0
Copper	2.3	0.03	0.54
Zirconium	0.12	0.01	0.063
Molybdenum	0.20	0.01	0.052

Table II — Materials of Possible Economic Value Found on the Ocean Floor

Material	Tonnage Estimate (Tons)	Remarks (Elements of Interest)
1. Red Clay	10^{15}	Cu, Al, Co, Ni
2. Globigerina Ooze	10^{14}	$CaCO_3$
3. Diatomaceous Ooze	10^{18}	SiO_2
4. Shark Teeth	—	P
5. Cetacean Earbones	—	P
6. Magnetic Spherules	—	Ni, Fe
7. Barium Sulphate Concretions	—	$BaSO_4$
8. Animal Remains	—	Rare Earths, Cu, Sn, Ni, Ag
9. Manganese Nodules	10^{12}	Mn, Cu, Co, Ni, Mo, V, Zn, Zr
10. Phosphorite Nodules	10^{11}	P, Zr
11. Coral Debris	—	$CaCO_3$

Table III — Composition of Phosphorite from Various Locations(1)

Constituent	Sea Sloor off California: Sorty Mile Bank	Santa Monica Canyon	Outer Banks	Land: Idaho	Florida	Tenn.	Russia
CaO	47.4	45.4	46.6	48.0	36.4	45.4	27.9
P_2O_5	29.6	29.2	29.1	32.3	31.3	31.0	17.9
R_2O_3	0.43	0.3	0.7	1.2	12.7	4.6	3.5
CO_2	3.91	4.01	4.54	3.1	2.2	2.2	3.7
F	3.31	3.12	3.15	0.5	2.0	3.8	2.0
Organic	0.10	1.90	0.44	—	6.2	3.8	3.2
Insol in HCl	2.59	3.57	3.57	—	—	—	—

(1) Weight percentages after Dietz, et. al., 1942 and Emery and Dietz, 1950. The dashes indicate analysis unknown.

but they will serve as a proving ground in developing techniques that can be applied to the mining of the vastly more important materials found in deeper parts of the ocean.

Importance of the California Phosphorite Deposits: It is largely a matter of transportation economics that makes the mining of the phosphorite deposits off Southern California an attractive venture. California has no deposits of phosphorite on land that are economic to mine but annually imports several hundred thousand tons of phosphate rock mines in Idaho, Montana, and Wyoming. While the mine-price of the mountain states' rock is about $8 per ton, the cost of shipping it to California points is about $7.50 per ton. As shipping charges in moving the submarine phosphorite to market would be a small fraction of the cost of shipping the ore in from the mountain states, these offshore deposits possess a great competitive advantage over material presently being mined for the California market. That is, of course, assuming similar mining costs for both areas. Some of the offshore deposits lie in less than 200 feet of water about 20 miles from Los Angeles.

The grade of the phosphorite found off California is remarkably uniform. Table 3 shows the composition of this material and, for comparsion, lists the composition of phosphorite mined in various other locations. As the California phosphorite contains about ten percent of water, simple drying of this material can raise its grade to the magic number of 31 percent P_2O_5 which, currently, is the standard for phosphate rock being processed into agricultural fertilizers.

Estimates of the total amount of phosphorite available for economic recovery from the California offshore area are somewhat speculative. The California offshore area probably holds about a billion tons of phosphorite with individual deposits probably containing as much as 50 million tons. Figure 1 shows the points where phosphorite has been dredged in large quantities off southern California. Figure 2 shows a map of the Forty Mile Bank deposit which lies about 40 miles west of San Diego. This deposit is of great interest because it contains a highly concentrated and relatively pure form of phosphorite nodules. Figure 3 shows a sea-floor picture of the phosphorite on Forty Mile Bank.

The California phosphorite occurs as nodules which vary in shape from flat slabs to irregular masses as shown in Figures 4 and 5. The smoothly rounded protuberances on the sides of these nodules indicate that they are the result of accretion rather than abrasion. Most of the evidence indicates that the nodules were formed in place. The nodules are firm, dense (specific gravity of 2.62), and of medium hardness (about 5 on the Moh scale). The nodules vary in color from light brown to black. Nodules from a particular area have a group resemblance especially in color, and range in size from oolites to chunks over a yard in diameter. The largest phosphorite nodule dredged off the

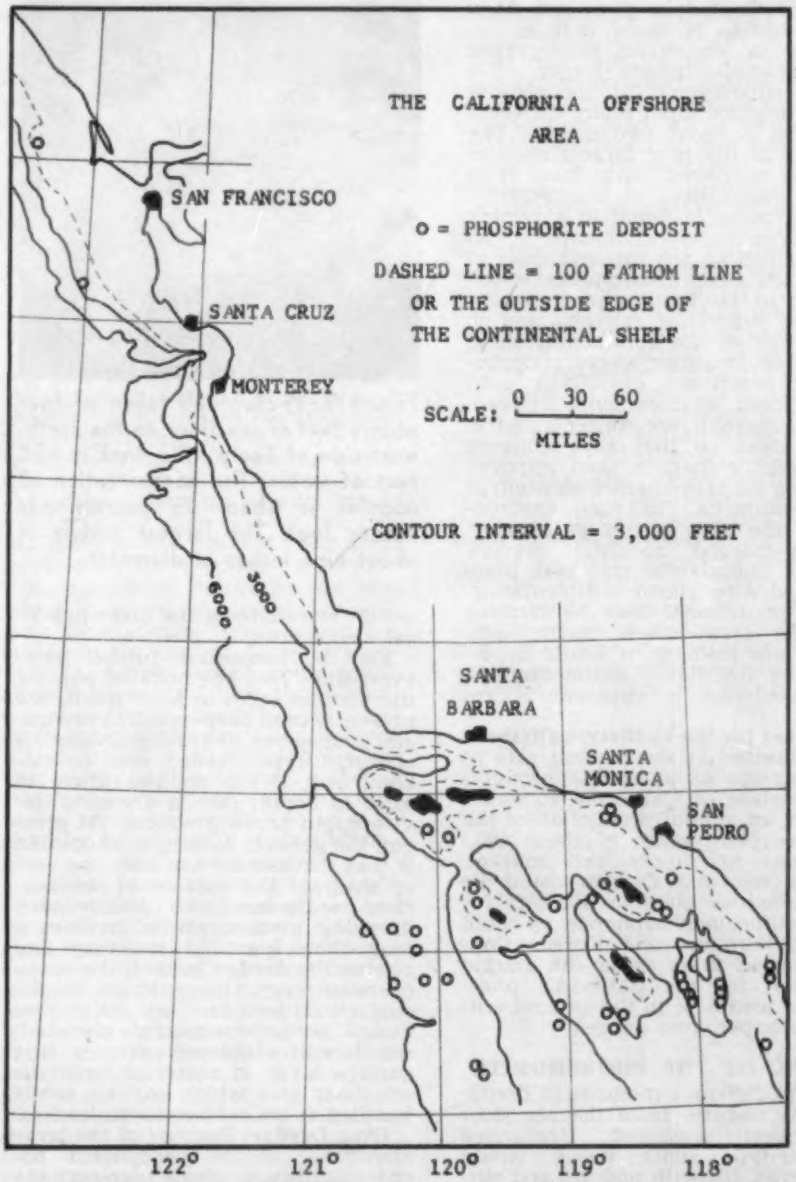

Figure 1. Map of the California offshore area showing the location and distribution of about 30 phosphorite prospects.

Figure 2. A topographic map of the Forty Mile Bank region showing the area in which commercially recoverable phosphorite should be found. The cross-lined area indicates the deposit which covers about 11 square miles.

coast of California measured 24 x 20 x 8-inches, however, nodules appearing in sea-bottom photographs are sometimes much larger. The average diameter of all the nodules so far dredged from many different locations is about two inches. The weights of the four largest nodules thus far recovered range from 77 to 160 pounds (Dietz, et al., 1942).

Phosphorite is found in a variety of topographic environments. It can be obtained on the top and sides of banks, on steep escarpments which appear to be fault scarps, on the walls of submarine canyons, and on the break of the continental shelf. All of the localities where phosphorite is found are essentially non-depositional environments. Ocean-bottom currents are concentrated in these areas so that any sediment that reaches them is soon removed allowing no permanent deposition of fine sediments. In such environments the slow accretion of electrically-charged colloidal precipitates of phosphorite may take place unimpeded by clastic sedimentation. While phosphorite may be forming in other areas where clastic sediments are forming, it would be diluted by the clastic sediments and, therefore, not be economic to recover.

Market for the California Offshore Phosphorite: At the present rate of consumption of phosphate products in the state of California it would require an annual production of the offshore phosphorite of about 400,000 tons to supply this market. Washington and Oregon could be considered as possible markets for the California phosphorite as could Japan, Formosa, and Korea. Considering all these areas, the market potential for the California phosphorite would be in the several million tons per year range.

MINING OF THE PHOSPHORITE

Many different methods of dredging the nodules from the sea floor have been suggested. Unmanned crawler-type units which would submerge, fill with nodules and surface; manned crawler-type bathyscaphes which would serve as the motive power to pull scraper units along the bottom; and large-tonnage submarines with manned spherical control chambers and flooded storage chambers into which the nodules would be pumped, displacing the water, were among the more practical suggestions.

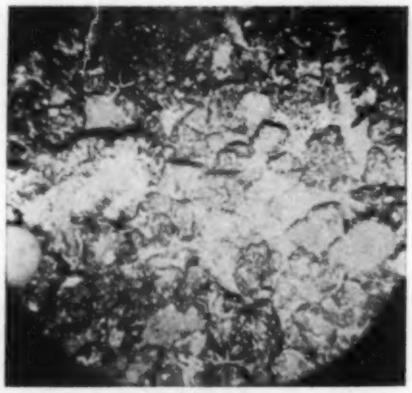

Figure 3. Photograph taken of four square feet of sea floor on the northwest side of Forty Mile Bank in 650 feet of water. The concentration of nodules is about 25 pounds per square foot. The largest nodule is about nine inches in diameter.

For the immediate future, however, only two methods of mining the nodules seem to have merit, the presently used deep-sea drag dredge, and a deep-sea hydraulic dredge. A clamshell-type dredge was considered, and, if the nodules prove to exist in depth, such a dredging device might prove practical. At present, the general consensus of opinion is that the nodules are only one layer thick at the surface of the sea-floor sediments. To justify any dredging process which involves a long time spent in lowering and raising the dredge bucket, the bucket must carry large loads to the surface. It will be very difficult to design a large capacity clamshell which will efficiently skim a thin surface layer of material from the sea floor and which can be safely handled at the surface for unloading.

Drag Dredge: Because of the large size range of the phosphorite nodules within a single deposit, the semi-developed technique of drag dredging appears to be the most attractive system to use in mining this material. The method is quite simple having been used by oceanographers with notable success for many years in depths of water ranging from a few tens of feet to over 30,000 feet. The general set-up of a drag dredge system is shown in Figure 6. With this system, the bucket would be lowered to the bottom, and, at the same time, the vessel would be steaming ahead to lay out scope in the line. When the bucket touches bottom, as determined by a sonic pinger attached to the bucket, or by a television camera mounted on the bail of the bucket, the vessel will stop paying out line and slowly steam ahead. When the bucket is full of nodules as determined by the line tension or by direct viewing with the TV camera, it is hoisted to the surface and emptied into a hopper on the dredging vessel. From the hopper, the ore is fed into a transfer system which carries it to a standby transport barge, where it is washed and stored.

The drag dredge is a very inefficient device for cleaning the sea floor. Dredge cuts would be taken almost at random in the deposit. Although some of the deposits are so vast that random dredging would be successful from a commercial standpoint, it is doubtful that the owner of the deposits would allow the use of this method if another more efficient method is available. A system of harness cables, as shown in Figure 7, might be used to control the location of the dredge bucket so parallel cuts could be taken through the deposit. Such a system, however, is fraught with risks of cable entanglements. Also, it would be expensive and time-consuming to develop the art of using this system efficiently.

The capital cost of a drag dredge system capable of mining at a rate of about 3,000 tons of phosphorite per day from a depth of about 600 feet, which is about the maximum possible production rate with a single drag dredge unit, would be about $2.5 million. This cost includes the dredging vessel and transport barges. The production cost of this method would be about $5 per ton of nodules. The bucket would recover about 30 tons of phosphorite per haul.

Hydraulic Dredging: Any large-scale, efficient operation to mine sea-floor minerals with present technological means would require some form of a hydraulic dredge. Normally, hydraulic dredges operate with a motor and a pump inside the

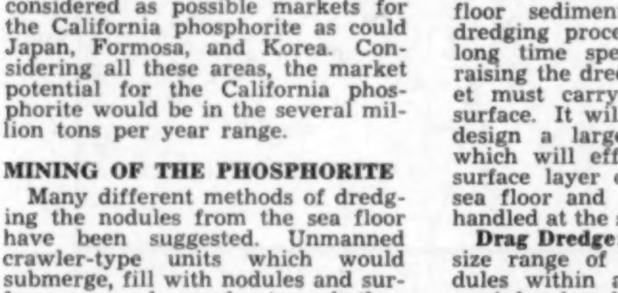

Figure 4. A large phosphorite nodule from the Forty Mile Bank deposit. This nodule weighs 62 pounds. The scale is one foot.

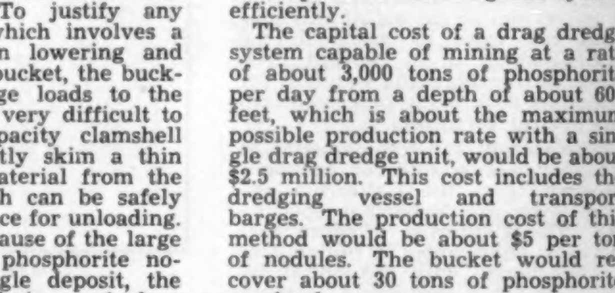

Figure 5. Phosphorite nodules from the Forty Mile Bank deposit. Slab-like nodules are common in this deposit, comprising about 40 percent of the nodules recovered.

hull of a vessel. The pump is generally located near or just below the level of the water in which the vessel is floating. Hydraulic dredges of this design are, consequently, severely limited to the depth from which they can pump solids. In general, hydraulic dredges work with an effective suction head of about 25 feet of water. If we neglect fluid friction and assume a 10 to 1 fluid-solids weight ratio in the pipeline, the maximum depth from which such a dredge could lift sediments, assuming a uniform density of the water at all depths, would be about 250 feet. The fluid-solids ratio could be increased and the dredge would lift solids from greater depths, however, power is being expended to overcome fluid friction as well as lift the solids in the pipeline and the point would soon be reached at which power costs far exceeded the value of the dredged material. Unless the depth of water is less than several hundred feet, therefore, the pump on any deep-sea hydraulic dredge must be submerged.

Although it must be submerged, the pump need not be operated near the sea floor. The factors controlling the location of the pump in regard to the surface of the ocean will be the fluid-solids ratio of the material in the pipeline and the fluid velocity at which the dredge is operated. It is advantageous from a number of standpoints to operate the pump as close to the surface as possible and for a fluid-solids ratio of ten to one, the depth of submergence of the pump would be about ten percent of the depth of dredging.

The major components of a deep-sea hydraulic dredge are a pipeline, pump and motor, suction heads, and a float. Although the weight of the dredge could be suspended from a floating vessel, such a system would be somewhat disadvantageous. Vertical oscillations of the vessel due to wave motions would be transmitted to the dredge introducing alternating stresses in the pipeline that might cause failure of the pipeline. Also, with such a system, the vessel and dredge are extremely vulnerable in case of a sudden storm. The deep-sea hydraulic dredge, therefore, should be supported by the main float, no vertical oscillations of wave motions acting on the stabilization float would be transmitted to the dredge as a whole. In case of a storm the control vessel could steam off and leave the dredge in place. A radio signal transmitter on the stabilization float would facilitate relocation of the dredge after the storm has passed.

The main float is over-sized and, thus, is ballasted with seawater to give the dredge proper trim. Should there be a failure in either the motor or pump, the ballast can be pumped out of the main float tank causing it to rise to the surface. A manhole at the top of the float tank would allow easy access by the crew to make repairs. In case of a sudden pump or motor failure, back flow valves along the pipeline would automatically open to vent the falling nodules and prevent them from packing in the pipeline.

As shown in Figure 8, the proposed hydraulic dredge is equipped with twin suction heads which fan out from the central delivery pipeline. The whole dredge would rotate around its central axis thus allowing the dredge heads to sweep a large area of the sea floor without a high lateral motion of the dredge. The lateral motion for such a dredge might be supplied by water currents in the ocean but could also be supplied by directionally controlled impellors along the pipeline.

A means of controlling the height of the suction head above the sea floor is included in both systems. Such control will allow the efficient cleaning of the nodule deposit without the removal of an excessive amount of the fine sediments on which the nodules are resting. Television cameras are also provided to watch the operation at the sea floor and to give the operator at the surface some means of controlling the dredge to take reasonably parallel cuts through a deposit without sweeping over a previous cut. Either of these systems of dredging would be applicable in any depth of water.

For the application of mining phosphorite nodules the dredge head could be a simple vacuum cleaner-type suction head which would fan out to a width about four times the diameter of the pipeline. The velocity of fluid flow in the pipeline necessary to carry the nodules to the surface is a function of the density differential between the carrying fluid and the transported solids and the square root of the diameter of the solids. Other factors such as wall effects, hindering effects, and sphericity factors will modify and lessen the fluid velocity necessary to support the nodules. With a 24-inch diameter pipeline, the maximum falling velocity of phosphorite nodules in seawater, considering the above mentioned factors, would be somewhat less than five feet per second. The upward flow of seawater in a pipeline of this diameter would be about 15 feet per second.

The pump required for this operation would be a standard dredge pump, however, the impellor blades would be faced with wear-resistant material. It is expected that the im-

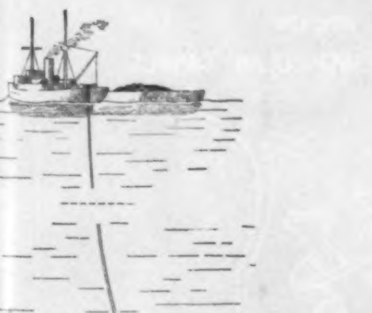

Figure 6. A schematic drawing of a drag dredge operation.

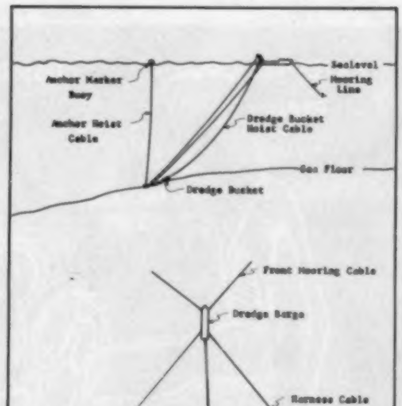

Figure 7. A schematic drawing of a cable harness system.

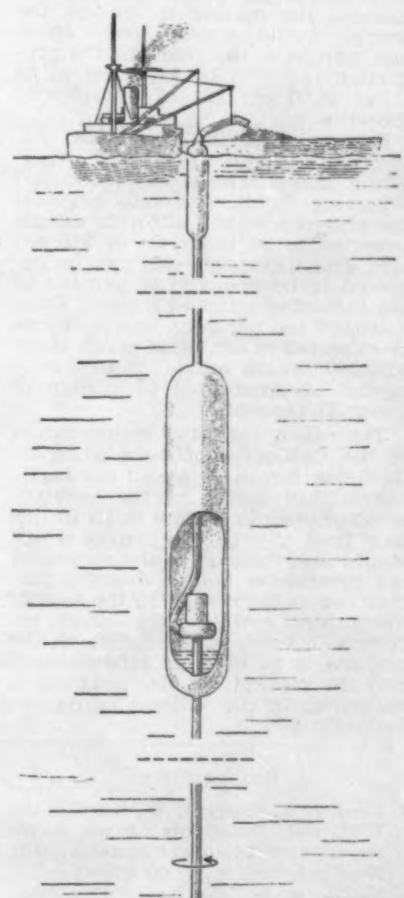

Figure 8. A schematic drawing of a vertical-float hydraulic dredge.

peller would last for several hundred thousand tons of production before replacement would be necessary.

When working in less than a thousand feet of water, it might be advantageous to support the dredge from the surface vessel. A splined slip section in the pipeline would serve to disconnect vertical motions of the vessel from the submerged part of the dredge. The slip-section would be spring loaded to prevent shock loads on the slip joint. The vessel would simply drag the dredge through the water. Television cameras, mounted on the dredge head, would view the sea floor and allow the operator some control over the location of the dredge head.

With a fluid velocity of 15 feet per second and a 24-inch diameter pipeline, the power required to operate the dredge in 600 feet of water would be about 1200 horsepower. The production rate of this dredge would be about 5,000 tons of phosphorite per day. The capital cost of the dredge, including the dredge vessel and transport barges, can be expected to be about $3 million. If allowed to operate at full capacity all year, the production cost would be about $2 per ton of phosphorite. Because the market is limited, the dredge would operate only about two months of the year and the production cost can be expected to be about $4.50 per ton of phosphorite recovered.

Economics of the Operation: Assuming the competition for the California phosphorite is the Idaho and Wyoming fields, the sale price of the phosphorite in California can be expected to be in excess of $10 per ton. The transport costs can be expected to be about $1.50 per ton of ore including unloading costs. Thus, a 400,000 ton per year operation can be expected to net, after taxes, about $800,000 for an annual return on a capital investment of $3 million of about 27 percent.

The major return of an operation in the California offshore phosphorite fields, however, would not be financial but would be the development of techniques and skills in this new field of sea-floor mining which would lead the way to the mining of the manganese nodule deposits further out in the ocean. In the case of manganese nodules, the gross recoverable value of the metals in the nodules is as high as $100 per ton and the market for the products is measured in the billions of dollars annually.★

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UNDERWATER NOISE CRITERIA

the man-machine team

By Robert Taggart

President, Robert Taggart, Inc.

AN ANTI-SUBMARINE SURFACE VESSEL searching for or attacking a submarine, uses echo ranging, or active sonar. In this type of sonar a repeated, high-frequency acoustical signal is sent out from the sonar transducer. If this signal strikes an underwater object, it will echo back and be received by the transducer. The time difference between the sending and the receiving of the signal is a measure of the target range; and the direction from which the echo comes is a measure of the target bearing.

For long-range detection of a target, active sonar is not satisfactory. The loss of signal strength, or attenuation, in sea water is excessive for high-frequency directional signals. In submarine versus submarine warfare the use of active sonar gives away the presence of the attacking vessel to the target. Thus for long-range detection, listening (or passive) sonar is employed.

Passive sonar consists of a transducer, or underwater microphone, an amplifying system, and a speaker or earphones. Through this system the underwater noise radiated by the target can be heard. Generally two or more transducers separated by a fixed distance are employed. These transducers are mounted in a horizontal plane and by measuring the phase difference in the signals received, the direction of the signal can be computed. In some types of passive sonar the transducer assembly can be rotated mechanically until the phase difference is zero, thus training the unit in the direction of the target. In other types the training is accomplished electrically with the transducers remaining fixed.

Since transducers of this type are generally omni-directional, the zero-phase difference position could indicate a target in either of two positions 180° apart. To prevent such confusion the back faces of the transducers are heavily baffled so that the noise arriving in the for-

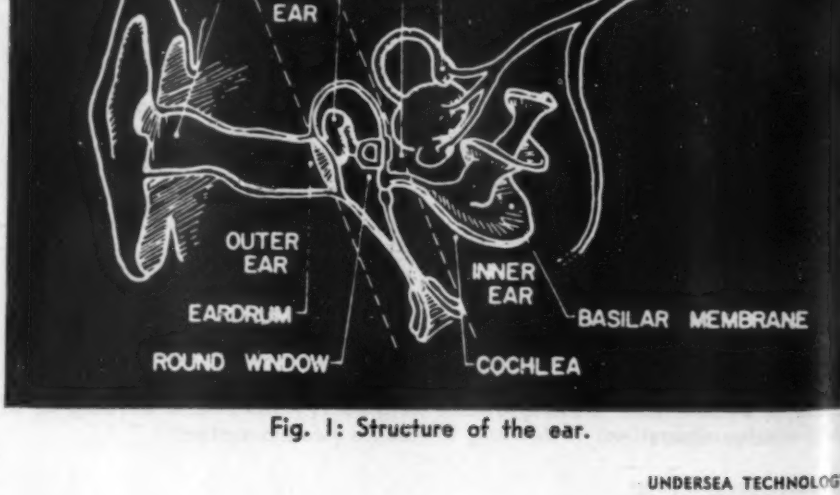


Fig. 1: Structure of the ear.

ward face of the assembly will far exceed that arriving at the after face. In other words, the baffling increases the front-to-back discrimination.

The human ear (Figure 1) is also important in the overall performance of a passive-sonar system. This performance is dependent upon the ability of a sonar operator to distinguish the sound of a target from the noises produced by his own ship. His ability to recognize certain sounds helps to identify the target. By discerning differences in frequency he can count propeller beats and often guess the speed of a target, and his estimate of relative loudness of a sound can help determine the bearing and range of a target. Thus the physics, psychology, and physiology of hearing are of extreme importance to submarine and anti-submarine warfare.

The young normal human ear can hear sounds at frequencies between 20 and 20,000 cycles per second. It can detect, as perceptible change in the pitch of a pure tone, a change in frequency of less than ½ percent. The ear is most sensitive at frequencies between 1,000 and 5,000 cycles per second; the range between the threshold of hearing and the threshold of pain is approximately 120 db at 1000 cps. A rapid change of less than one decibel in the level of a pure tone can be perceived at a comfortably loud listening level.

The ear is like a microphone, frequency analyzer, and sound-level meter. In a simple sound-level meter system, the lowest signal which can be measured is determined by the microphonics and electrical self-noise of the system; that is, the signal must be of an intensity greater than the self-noise in order to be measured. This lower limit is termed the threshold of the system. The human ear also has a threshold which is determined by the self-noise generated by muscular action and the movement of the circulatory and respiratory systems.

The microphone sound-level meter

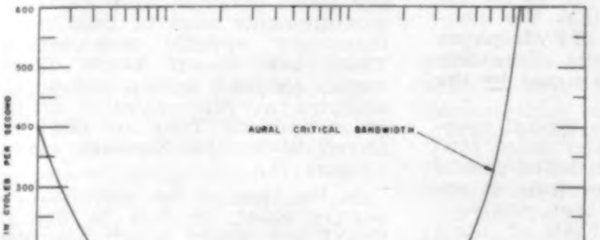


Fig. 2: Aural critical bands of the human ear.

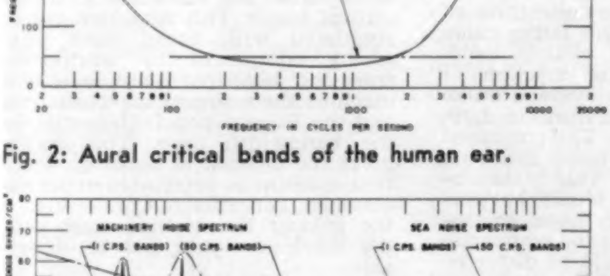


Fig. 3: Machinery noise in presence of sea noise.

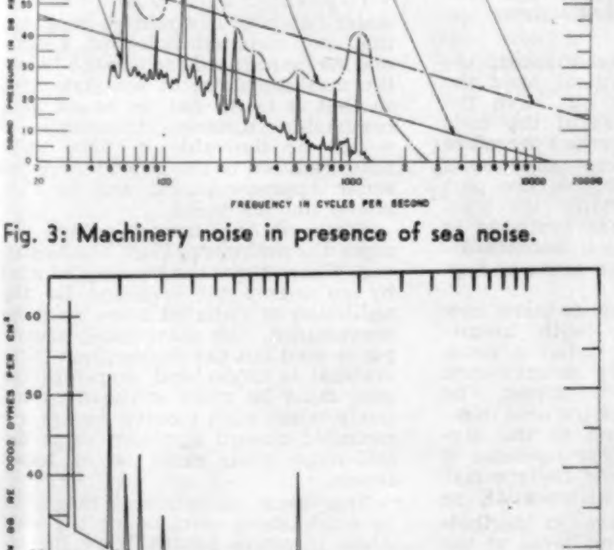


Fig 4: Machinery noise + sea noise (1 cps bands).

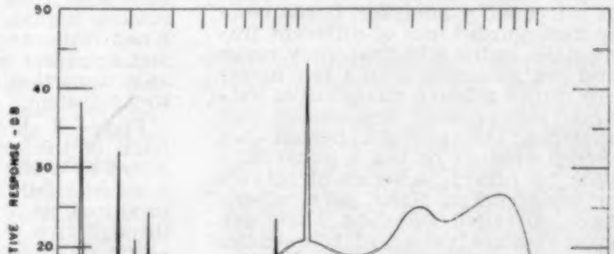


Fig. 5: Machinery noise + sea noise + sonar response (1 cps bands).

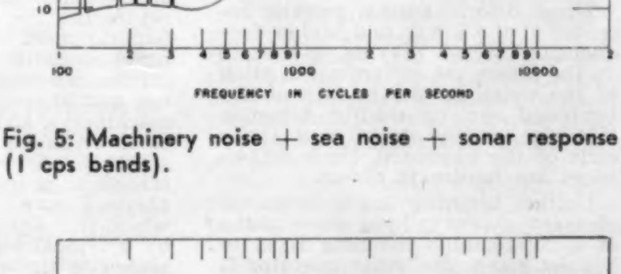


Fig. 6: Machinery noise + sea noise + sonar response + ear response (50 cps bands).

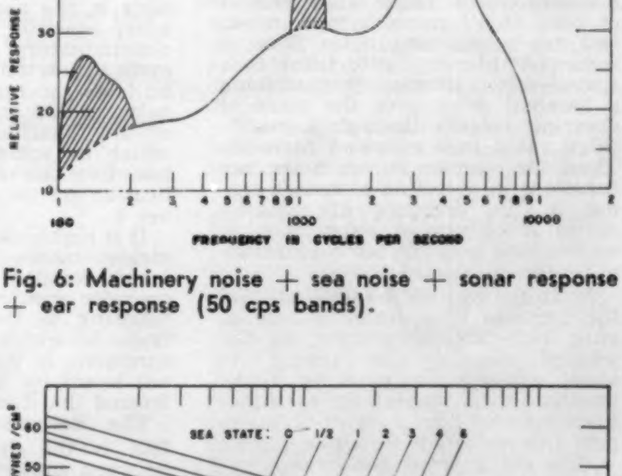


Fig. 7: Average spectrum levels of ambient sea noise.

system also has an upper limit of usefulness. At high sound-pressure levels the amplifiers become blocked and the meter will no longer function accurately. Permanent exposure to such levels can destroy the sensitivity of the instrument. The human ear also has an upper limit of usefulness. The level at which this occurs is called the *threshold of pain*. If the ear is often exposed to levels in this region, permanent deafness or loss of hearing can result.

Both the threshold of hearing and the threshold of pain vary with frequency as does the most comfortable listening level.

As noted before, the ear functions as a frequency analyzer. It can easily distinguish tones of different frequencies in the mid-frequency range and can generally give a fair measure of the relative quantitative value of two or more frequencies. For example, the average person can detect whether or not a piano is in tune by playing a series of octaves or basic chords. Some persons who have so-called *absolute pitch* can give absolute values of frequencies in the mid-frequency range when they hear a single pure tone or a chord.

These discriminatory powers decrease at the lower and higher frequencies. When playing the scale on the piano, the difference in pitch of the notes in the middle of the keyboard can be readily detected. However, at the upper and lower ends of the keyboard, these differences are harder to detect.

Unlike listening to a series of pleasant chords played on a piano at a comfortable listening level in a quiet room, the sonar operator is trying to hear and identify a complex signal through a group of masking noises. These noises consist of own ship's noise, system noise, and sea-background noise. This is somewhat like trying to listen to a gravel-voiced announcer describing a baseball game over the noise of cheering rooters through a static-filled radio in a crowded barroom. Thus, the manner in which the ear functions in detecting a wanted signal in the presence of masking noises is of utmost importance in establishing criteria for submarine-noise measurements.

As in the case of the baseball fan, the ear can hear many sounds at once but can concentrate on the wanted sounds, disregarding, to some extent, the masking background. In this respect, the ear functions somewhat as a series of band-pass filters—accepting those signals within the desired bands, and rejecting those outside of those bands. This can result in better discrimination of a wanted signal in the presence of a masking background.

The band of frequencies which the human ear passes is termed the *aural-critical band* (Figure 2). This band, however, is not the same at all frequencies. It is much narrower at the mid frequencies of the audio-frequency range than at the high and low frequencies. In order to compare available instruments to the human ear, a constant value of 50 cycles per second may be used as a substitute for the aural-critical band. This represents a fair average of those bands which are of general interest.

To return to the sonar operator, the underwater sounds heard by him are not directly comparable with the sounds produced. He is listening through a series of electronic components which distort the sound radiated by the target. The response of the hydrophone itself tends to reshape the arriving signal in a manner which lowers the intensity of the low-frequency components. The amplifier circuit contains several elements which can vary the character of the signal. In most sonars the operator can select the response position which is most satisfactory for listening to the incoming signal, and thus the combined response curve of hydrophone and amplifier represents a considerable distortion of the signal by the sonar system.

Figure 3 shows the typical spectrum of the underwater noise produced by a machine installed aboard a submarine. This spectrum is reproduced as it has been analyzed through two different sets of filters—one which hears the noise in bands which are one cps wide, and the other which hears the noise through 50 cps bandwidths. This latter value represents the aural critical band. Superimposed on the machinery-noise spectrum is an average value of the sea-noise spectrum in both one and 50 cps bands. The combined machinery- and sea-noise spectrum is shown in Figure 4. This is the absolute signal which might be presented to a passive sonar hydrophone. Figure 5 shows the manner in which this signal would be distorted by a typical sonar system and presented to the ears of the sonar operator.

Because of the total masking effects in the aural critical band the sonar operator does not have the discriminatory powers of the one-cycle bandwidth filter and therefore he loses the machinery noise peaks between 250 and 900 cps. The part of the machinery-noise spectrum which he actually has available to him to make detection and identification are the shaded areas of Figure 6.

It is highly desirable to know how measurements made with instruments compare with what a sonar operator can actually detect when listening to the same noises. The factor by which the instrument measurement is compared to the signal heard by the sonar operator is termed the *Recognition Differential*.

The Recognition Differential, or RD, is the difference in decibels between the wideband level of the masking noise and the level at which a listener can distinguish a signal at least half the time. For example, if a listener were exposed to a mixed sound of sea noise and the noise of a machine, he might be able to recognize the machine noise even though its wideband noise level was 12 db lower than that of the sea noise. In this case the Recognition Differential would be −12 db if he could do the same thing in five out of ten tests.

This same experiment can be made using narrower bands for listening to both the masking noise and the machine noise. As the width of these bands approaches the aural-critical band the Recognition Differential will come closer and closer to a zero value.

Assuming that sonar designers are successful in reducing system noise to a minimum and that the noise reduction program succeeds in lowering own ship's noise, the remaining masking noise which must be contended with is the ambient noise of the sea itself. This is a randomly fluctuating noise which varies with the state of the sea and which generally decreases in level with increasing frequency. In order to deal with it practically, many assumptions must be made. First, the average levels obtained from numerous measurements must be used rather than any specific measurement. These are shown below. These curves are well known and widely accepted as representative of the ocean ambient. They are often referred to as the *Knudsen* curves (Figure 7).

In the case of the operator of a passive sonar, he may be able to detect any sound which has peak levels greater than the sea noise when both are analyzed in aural-critical bands. This condition can be simulated with broad band measuring equipment by subtracting from the measured noise level of a machine the assumed sea-noise level and the Recognition Differential for the bandwidth used. The answer gives the amount of noise by which that machine is detectable under the assumed conditions. Conversely, if the answer so obtained were zero, the machine would not be detectable.

To establish a true goal for underwater listening it would be desirable that the radiated noise of a submarine be reduced far enough below the masking noise of sea-state zero so that it could not be heard at a reasonable distance. Similarly it would be desirable to have self-noise reduced to the point where the sonar operator could not hear it above the sea noise.

Some of the newer sonars are more discriminatory than the human ear. Where these sonars may be used by an enemy the criterion for the reduction of radiated noise must be reexamined. The same basic principle is used but the Recognition Differential is larger and therefore the goal must be more stringent. Similarly when such passive sonars are mounted aboard our own ships the self-noise goals must be at lesser levels.

This same principle is employed in establishing criteria for the self-noise in active sonars. Here the effort must be concentrated at the frequency of the sonar signal. The principle also holds in establishing criteria for mine and torpedo protection where the detection capability of the acoustical systems in the weapons must be taken into consideration.

Fundamentally the goal for silencing of all naval ships is to keep the noise level at the point where it cannot be detected at a reasonable distance by whatever detector might be used in the presence of the lowest level of ambient sea noise which might be anticipated.★

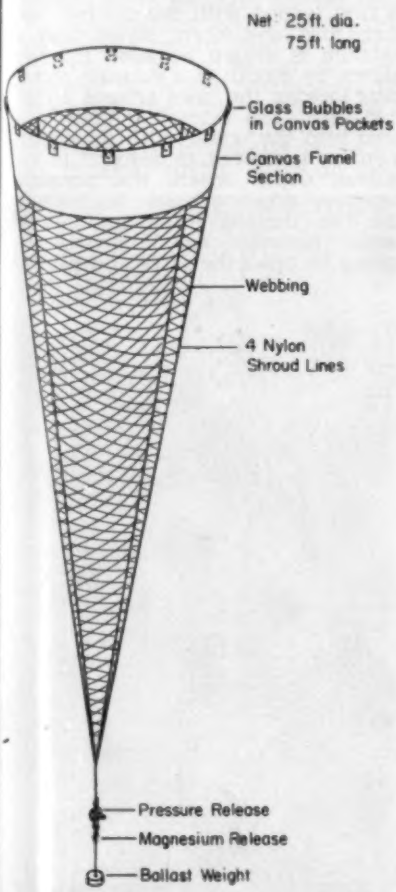
Free sampling net after release.

UNDERWATER REMOTE PROGRAMMING

by George B. Schick & John D. Isaacs

Scripps Institution of Oceanography

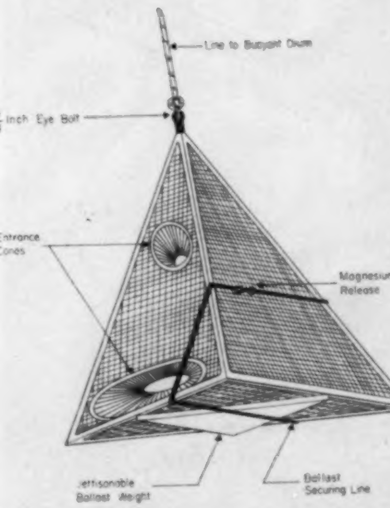
MAN'S DESIRE TO PENETRATE THE DEPTHS of the sea has led to development of many ingenious devices to perform mechanical operations in that remote environment. As long as sampling and measuring gear were lowered into the sea on cables, reversal of thermometers and closing of nets and water samplers could be accomplished by a messenger-tripping system. The messenger "switch", however, essentially a single-channel pulse-type control system, is quite limited as to the complexity of operations that it can perform. A messenger system capable of controling more than one instrument is cumbersome, and one capable of delivering two seperate signals to more than one instrument becomes most complicated and unreliable. To perform more sophisticated operations in the sea, electrical hoisting cables were developed; but due to the many problems associated with electrical controls of instruments, electrical cables and the necessary winches are not yet in general use on oceanographic vessels.



Free net 25 feet in diameter and 75 feet long before release showing redundent release system.

Development of free instruments (Ewing and Vine, 1938; Isaacs and Schick, 1960; Moore, 1960; *Oceanus*, 1960) and the necessity of controlling them has led to the design of a number of control devices actuated by pre-determined environmental cues such as time and pressure. Since these devices do not rely on cable contact with the surface they can also supplement the messenger system and give the oceanographer another channel of control over his instruments, even though they may be lowered by cable.

Magnesium time-delay release: Physical processes such as melting of ice, dissolving of salt and even candy have been used to trigger delayed-action releases. Many clockwork devices likewise have been used to produce a delayed mechanical motion. An interesting release that depends on the controlled electrolytic corrosion of a magnesium link was described by W. G. Van Dorn (1953).



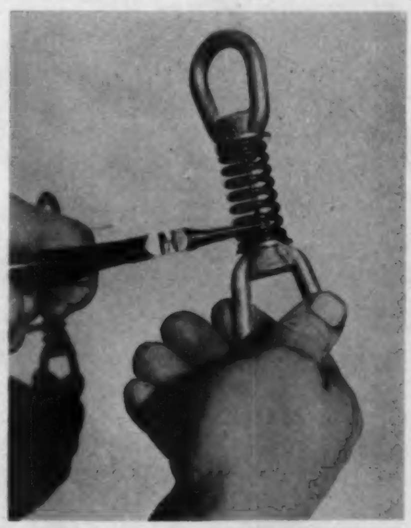
System for releasing bottom trap showing use of magnesium release to drop ballast weight.

During the development of the deep-free vehicle at Scripps Institution of Oceanography, the requirement to release a ballast weight from a bottom trap, which was sitting flat on the floor of the ocean, made it necessary to develop a simple and reliable release device that was inexpensive enough to be expendable.

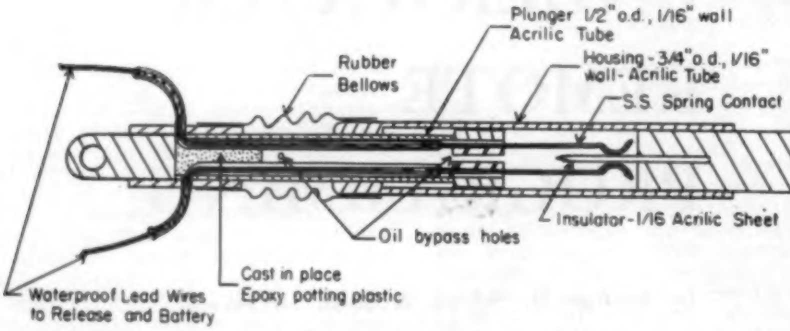
The time release that was developed also makes use of the electrolytic corrosion of a magnesium link.

The link is made from a piece of three-eighths inch magnesium rod alloy AZ 31B. Threads are first cut on both ends of the link and it is then turned down to the desired diameter in a lathe. Other fittings are standard hardware items, the complete unit costs less than two dollars.

The magnesium release is assembled as follows. One of the eye-nuts is screwed onto the link and both



Close up of assembly magnesium time release. Note extreme simplicity of the mechanism.



Details of oil-filled deep sea pull switch.

washers and spring are slipped over the link. The other eye-nut is then screwed on loosely. Finally a special pair of longnose pliers is inserted through the spring to grip the link at the root of the tread as shown in fig. 2, and the eye-nut is screwed tight, compressing the spring to one and three-fourths inches. The longnose pliers are used to prevent the fragile link from being torsionally strained or possibly broken during assembly.

Care must be taken to use a standard #68 spring with the natural black-steel finish and not one which is cadmium plated or made from stainless steel, since the spring material determines the characteristics of the electro-chemical cell.

The calibration curve for the magnesium time-release with the specified spring is shown in the accompanying graph along with the calculated breaking strength. The use of a different spring will require recalibration of the release. The release is of course sensitive to the tensile forces imposed by the weight while lowering, and the buoyancy while on bottom. Since it was designed for use with light loads the effect of the load on the release delay time can be neglected. For heavier loads this would not be so. The calibration curve is given for different temperatures and is a result of 75-to-100 laboratory tests.

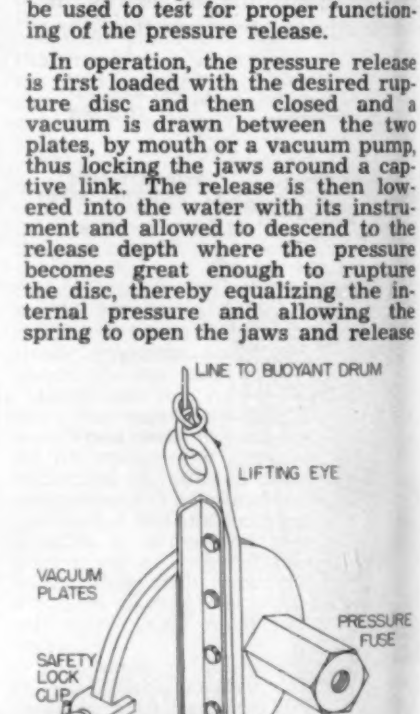
Physical factors such as agitation of the water, depletion of chemical constituents of the water, and saturation of the water with the chemical products of the reaction were ignored in these tests. The solid lines in fig. 3 show the minimum expected release delay time. The variation that can be expected in minimum release delay time is in general $+20\%$ -5% of the time indicated on the curve. The probability that the release time will fall within $\pm 5\%$ of the indicated time is about 75%. The errors in timing are due to variations in fabrication and assembly and also to the rather large inherent error due to the variation in tensile properties of the magnesium link. There is more variation than perhaps is desirable in the time of release but there is no uncertainty as to eventual release. The simplicity and inexpensive construction of the magnesium release make it quite useful in applications where extreme accuracy of time delay is not important. Its use as a safety link to back up other types of releases and thereby prevent costly losses of instruments should also prove to be of considerable value.

In the usual application the release is simply tied to the line somewhere between the weight to be released and the instrument. The arrangement shown in the accompanying diagram has the advantage of reducing considerably the tensile forces imposed on the release by the weight, especially during launching.

Pressure release: Another more recent development in the field of remote control devices is the pressure release. This device is designed around a pressure fuse. The pressure fuse is a standard high-pressure pipe fitting that makes use of a thin-metal rupture disc whose rupture pressure can be accurately determined experimentally. Stainless steel discs are available commercially rated at a wide variety of rupture pressures above three hundred psi and a guaranteed accuracy of plus or minus two per cent. For lower pressures, precious metal corrosion-resistant discs are available but satisfactory operation has been achieved with discs punched out of heavy-gauge aluminum foil, since the discs are subject to corrosive salt water for only a short time. These are very inexpensive to fabricate and can be easily calibrated by connecting the pressure fuse to a high-pressure pump in the laboratory and noting the rupture pressure of several discs punched from the same piece of material. This procedure should also be used to test for proper functioning of the pressure release.

In operation, the pressure release is first loaded with the desired rupture disc and then closed and a vacuum is drawn between the two plates, by mouth or a vacuum pump, thus locking the jaws around a captive link. The release is then lowered into the water with its instrument and allowed to descend to the release depth where the pressure becomes great enough to rupture the disc, thereby equalizing the internal pressure and allowing the spring to open the jaws and release

Simple device demonstrates predictable actuation time.



Perspective view of remote pressure release mechanism.

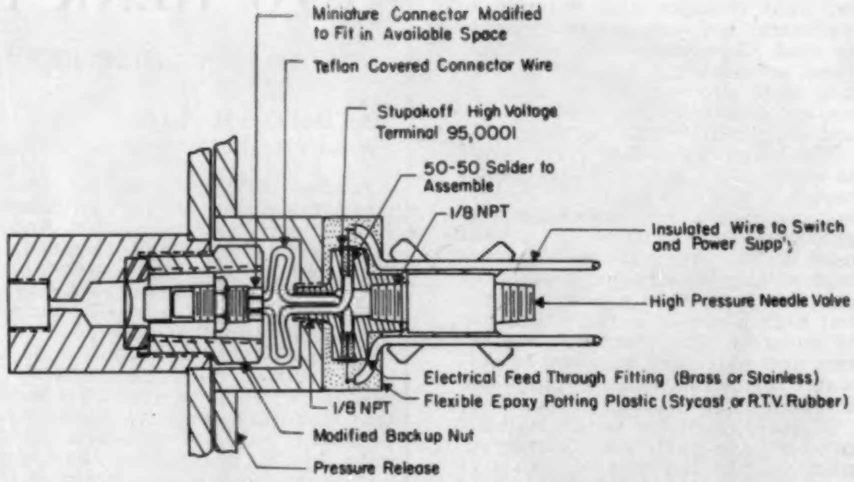
the captive link. The model shown in the drawings was designed to lift a maximum of five hundred pounds and launch it over the side of a ship. Adequate safety precautions should be observed when handling such heavy loads since a small scratch on the O-ring seat or other small imperfections could cause a leak and result in premature release while launching in rough sea. The release can be locked during launching by a small C-shaped spring clamp tied to a tag line and removed after the load is clear of the ship.

Application. This device was designed specifically to release a ballast weight from a large free net that was launched from a ship and allowed to sink to a pre-determined depth. Buoyancy was provided by a large number of hollow glass spheres distributed about the upper edge of the net in canvas pockets. When the net reached the desired depth the ballast weight was released and the net returned to the surface much like an inverted parachute. For application such as this, a magnesium release can be used as the captive link thereby preventing the loss of the equipment if the pressure release fails. The pressure release has also been used to open a one-half ton water sampler and will be similarly employed to open a 60 ton water sampler which is under development at Scripps Institution.

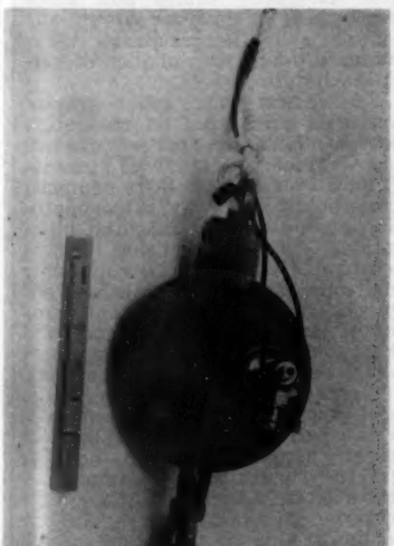
Another interesting underwater operation which is now possible, would make use of both the pressure release and the magnesium time-release to program the mission of a free-drifting sub-surface vehicle able to record data or gather specimens. This operation can be performed with equipment that is now operational and would be carried out as follows. The complete free-vehicle system would be carefully weighed under water to determine the amount of added weight necessary to make it neutrally buoyant. This amount of weight would be fixed to the specimen trap in the conventional manner with a magnesium time-release with four hours or so time delay. An additional depressing weight would also be fixed to the system with the pressure release. The vehicle would also be launched where upon it would descend to the pressure-release depth and release one weight, and become neutrally buoyant. It would tend to drift along at this approximate depth until the time release dropped the second weight and allowed the vehicle to return to the surface. A mission such as this could trap specimens from the deep-scattering layer for instance, or from other narrow strata which are difficult to sample with present equipment.

Electrical release: The third programming device with which this paper deals was developed by modifying the pressure release so that it could be triggered electrically. The modification is a bolt-on attachment which allows the same piece of equipment to be used as a pressure release and an electrical release. The electrical attachment triggers an explosive charge which ruptures the disc.

The only part of the pressure release which must be modified is the backup nut. It is drilled and machined to accept a threaded bushing. The bushing is designed to receive an explosive squib and position the squib so that its explosive force will drive a piston through the rupture disc. Stainless steel discs were successfully ruptured in a test with a two-grain power charge while under five thousand psi hydro-static pressure. (Testing is not yet completed on this modification.) A rupture disc which is about ten to twenty



Details of electrical feed-through fitting.



Magnesium and pressure devices in series with pressure released closed.

Photo shows pressure release mechanism in the open position. This is also the model with the electrically actuated squib.

per cent stronger than required to withstand ambient pressure should be used. To complete the modifications, an electrical feed-through fitting must also be installed. It is installed between the needle valve and the pressure-fuse housing.

The electrical release is connected in series with a switch and power supply. A dry battery of proper voltage which has been pressure-protected by potting in tar can be used as the power supply. A small high-voltage battery and a capacitor can also be used as a power supply but such a circuit is more sensitive to moisture. The electrical connectors and plugs are standard underwater fittings such as Joy plugs and Stupakoff high voltage terminals.

The design of the switch will depend on the particular release application. In the case of the large water sampler, the release was used to stop the filling operation and close the valve. It was necessary to perform this operation when the bag-like sampler became full, so a simple pull switch was designed. The switch was fastened to the side of the bag in order to make use of the increasing tension as the bag became full to close the contacts. Switches can be designed to respond to bottom contact or other mechanical, thermal, or pressure signals. These will make the electrical release of general use in oceanographic instrumentation.

Accurate and/or extended release delay times can also be achieved by connecting the release to a clock actuated switch. A chronometrically-governed motor could be modified to trigger the release after long periods of immersion such as a month or a year and return data and instruments to the surface for recovery. Such operations as measuring the rate of sedimentation or serially photographing the ocean floor could conceivably be carried out.

As a result of this line of instrument development the oceanographer can look forward to a time when he can purchase instruments (off the shelf), and make measurements or take samples anywhere in the ocean quickly and at more-reasonable cost, unhampered by the need for large ships and long cables and unencumbered by their limitations. ★

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Manufacturing detail drawings of the pressure release mechanism, magnesium time release, and back-up nut modification are available for $1.25 prepaid per set to handle blue-line copying, postage and handling charges.

NOW HEAR THIS

science, engineering & oceanography

By Robert M. Snyder
Woods Hole Oceanographic Institution

OCEANOGRAPHY is rapidly approaching a state of activity comparable with modern industry. And this movement is not necessarily restricted to the industriousness of oceanographers. Recent worldwide publicity has not only made the public aware of the fact that the ocean is more than a moderately flat surface, but is has made the oceanographer aware of the fact that his future expeditions and experiments will be watched, not only by his colleagues, but by newsmen, industrialists, and politicians. This publicity will be neither wholly beneficial nor wholly harmful to the science, but a little bit of both.

The eyes of the people, though sometimes discomforting, should be welcome. For why do we carry out research except to enlighten ourselves and our fellow inhabitants of this good green planet? And the man on the street is not nearly as stupid as the success of some Madison Avenue techniques would tend to indicate. If newsmen stick to the news, and we and our colleagues can remember why we chose this vocation in the first place then this aspect of the publicity can only be beneficial.

The grand scale of oceanic instrumentation envisioned by the oceanographer of today must naturally attract the attention of the industrialist. Many thriving businesses of today were brought about specifically to solve aircraft, missle, and undersea technological problems for the government. The manufacture of instruments designed for pure research in the oceans is a natural next step. In my opinion, however, the main role that industry can play in oceanographic research itself lies in specific contractual studies for various government agencies. For the arm of an octopus which asserts independence and ceases to contribute to the well being of the whole will soon atrophy.

Benefits to the science of oceanography wrought by industry will come from the manufacturer's eagerness to beat his competitor to the punch and also from the sincere interest of some of the scientists and engineers in industry to solve well a challenging problem.

Harm to oceanography—and this I believe to be quite realistic—*could* come from the willingness of the oceanographer to lay all his technical problems in the hands of industry for the purpose of releasing himself to more *sophisticated* pursuits.

There are many good reasons why the basic engineering required at present in the field of oceanography should be carried out at the research institutions themselves.

Oceanographic science has reached the point of diminishing return in respect to theoretical studies and sampling type experiments. And technological advancements of the last decade have made possible the testing of many theories to a degree of thoroughness undreamed of 20 years ago. Take, for example, the gross circulation of entire ocean basins where statistical sampling techniques are vastly inadequate. These ocean basins must be completely fenced off with current measuring devices and weather recording stations. Certain other instruments such as temperature-depth recorders are desirable, if not absolutely necessary. Obviously, in such a program, once the experiment has been defined using sound scientific judgement it becomes essentially an engineering problem.

The steps involved between a hot idea in the brain of a scientist to a reliable instrument in the cold depths of the ocean are many and diverse. If the scientist is blessed with common sense and some mechanical ability and is given the proper tools he can accomplish the necessary steps with the greatest of efficiency given the proper tools and equipment.

The next best arrangement for the scientist is to have competent assistants with appropriate experience who can *understand* the problem with a minimum of elucidation and fulfill the requirements using their own innovations.

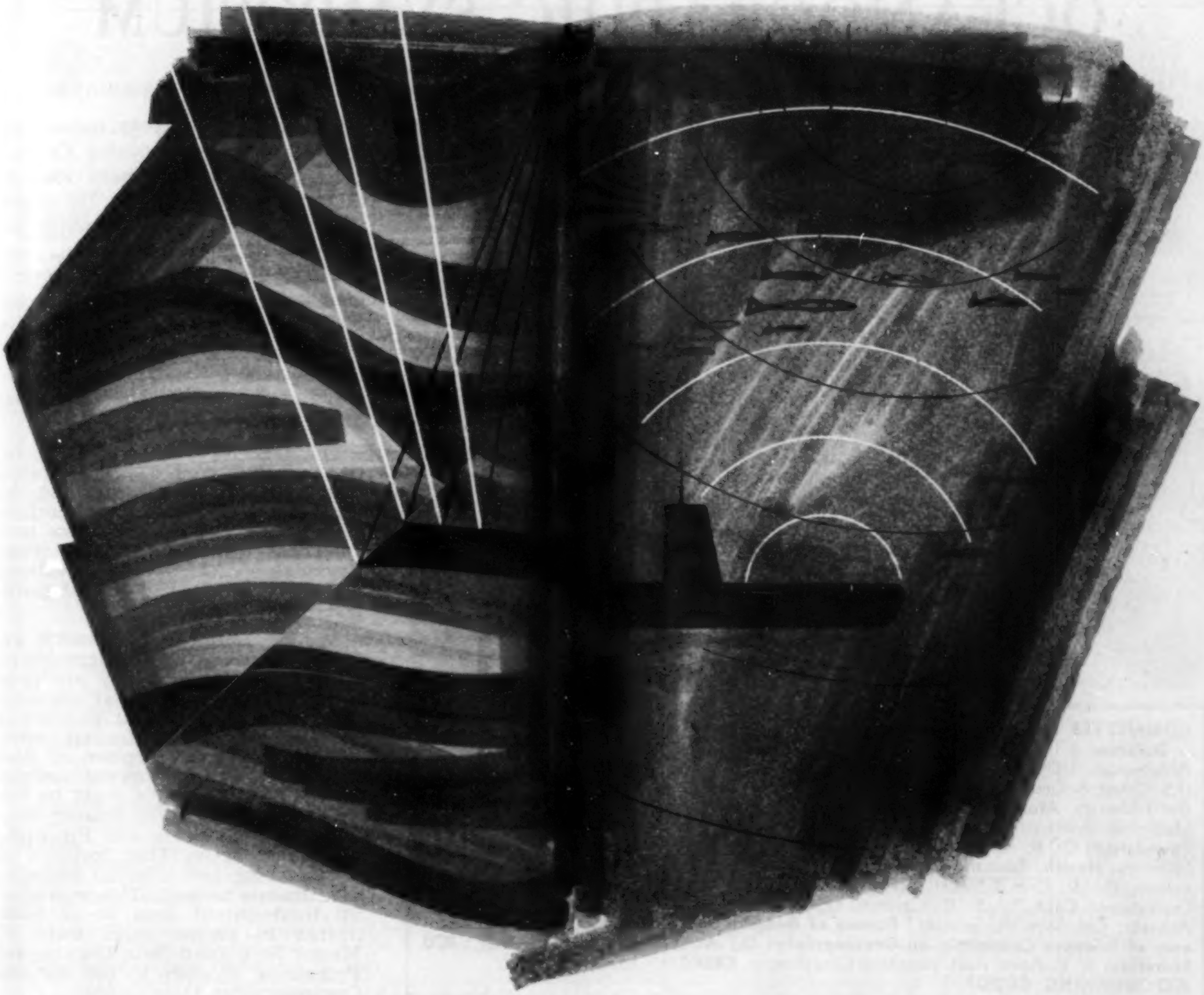
Beyond this the scientist must rely, essentially, on people outside his field to do his engineering for him. The only things bad about this are: It is time consuming and costly, and the scientist today stands a damn slim chance of getting what he wants.

Some first rate oceanographic scientists are also first rate engineers—others are not. As concerns the engineering level of oceanography I strongly believe competition should give way to co-operation among various research institutions. But competition among companies who wish to contribute instruments and materials is highly desirable and should be promoted; and for their own good and the good of industry, oceanographers should be difficult customers.

Good engineers with a scientific background and good scientists with engineering ability should be eagerly sought after by the oceanographic institutions. Engineering has definitely become a major part of oceanographic research. Failure to admit this or to underestimate its significance is surely a step backwards. The help of industry should certainly be sought, but only as an aid to our inspirations and not as a replacement for them.

About the eyes of politicians—all I can say is that they sometimes seem to be crossed.

The opinions in this column are the private ones of the author.



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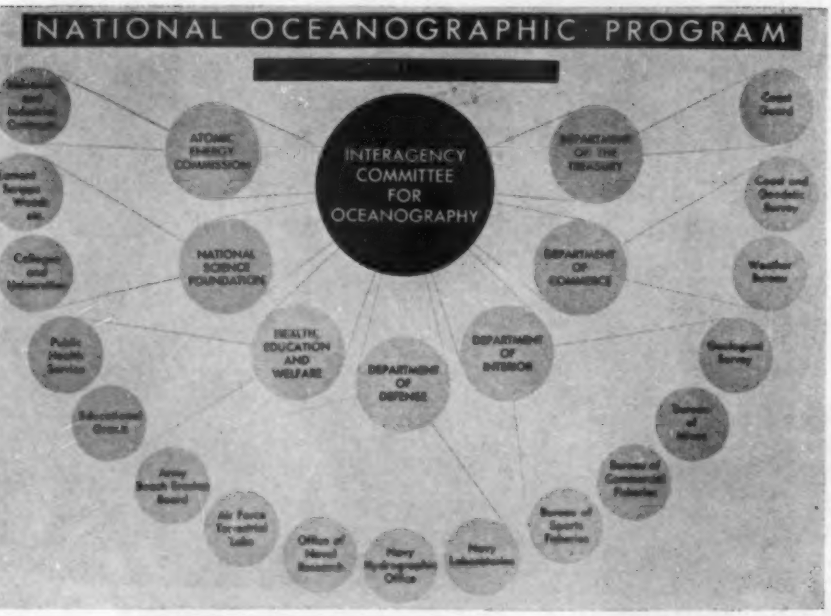

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[1]Alternate, [2]Observer

DURING THE TWO HECTIC DAYS of the first Government-Industry Oceanographic Symposium, there were 24 talks made before some 700 representatives of industry. Concerned entirely with instrumentation, they discussed the drastic need for instrumentation improvement. It would take several hundred pages to give descriptions and specifications of all the required instruments, but a coverage of some will give the general idea.

The U.S. Navy Hydrographic Office has compiled a list of instruments and systems required for three types of ships that perform oceanographic operations. (see table I). These ships are: Survey Ships, Regional and Mobile Observational Ships (ASWEPS), and Ships-Of-Opportunity.

Survey Ships are intended expressly to perform oceanographic research and survey. They are to be equipped with the most elaborate and reliable equipment possible. A general requirement for all instruments, with the exception of those concerned with gathering samples, is that collected data must be able to be read into the Master Shipboard Data Logging and Processing System directly. This includes all telemetering and internal recording instruments as well. This will allow all final output data to be transmitted in proper form from the Master Shipboard Data Logging and Processing System to the National Oceanographic Data Center.

Modular construction of sensors and consoles is specified for several reasons.

- Facilitate field maintenance and repair.
- Greater accuracy can be achieved more economically with modular group. Each sensor can be interchangeable and cover different ranges.
- Standardization will increase application and market.

All instrument or system vehicles such as buoy, floating stations, etc., must be capable of accomodating all standardized sensors, recording equipment, transmitters and other relative components. Other design factors which must be considered are long life and accessibility for fast, accurate calibration.

ASWEPS (antisubmarine weapons environmental prediction systems). This is a shipboard oceanographic synoptic system for regional and mobile observational networks, designed especially for collecting and reporting key oceanographic data. This system will be used by ocean station vessels, radar picket ships and selected combatant Fleet units. The system must include, but not be limited to:

a) Modular sensor (depth, temperature, sound velocity, conductivity)
b) sensor housings

OCEANOGRAPHIC INSTRUMENTATION REQUIREMENTS Compiled by U.S. Navy Hydrographic Office	U.S. Navy	U.S. Coast & Geodetic Survey	Scientific Community*	Coast Guard	Commercial Fisheries	USAF Ocean Range Vessels	Atomic Energy Commission	Other	Total
Type Ship/Instrumentation									
SURVEY SHIP									
Individual Components									
Hydrographic Scanning Echo Sounder	19-25	2-6	10-15		2				33-48
Current Meters	50-250	15-30	20-40		15-50				100-370
Shipboard Wave Meters	20-30	10-15	10-15	15-30	2	6-8			63-100
Constant Tension, Heavy-Duty Winch	15-30	6-15	10-20		2				33-67
Sub-Sea Floor Strata Profiler	20-30	10-15	15-30						45-75
Shallow Water Echo Sounder, Portable	20-40	15-30	10-20	10-20	10-30				56-140
Gravity Meters	10-20	2-3	6-15			6-8			24-46
Marine Electron Resonance Magnetometer	20-40	10-20	10-20						40-80
Deep-Diving Sensing Instrument, Self-Contained	20-40	10-200	10-20		30-100				70-360
Surface Navigation & Buoy Location Transponder	20-200	10-20	10-20	10-20	10-100				60-360
Shipboard Dye Detector Probe	20-40	10-20	10-20		2-14		10-20		52-114
Deep Sea Plankton Sampler	19-22	8	12-20		2-20				41-70
Shipboard Gamma Ray Detector	20-40	10-20	10-20		2-8		10-20		52-108
Radioactive Water Sampler	20-40	10-20	10-20		2-10		20-40		62-130
Underwater Camera	20-40	10-20	10-20		2-8				42-88
Sea Floor Sampling System	19-22	8-15	12-20		2				41-59
Sea Floor Geothermal Probe	20-30	10-15	10-20						40-65
Systems									
Oceanographic Survey, Shipboard	20-40	10-20	10-20	10-20	2-10				52-110
Precision Navigation Control	20-40	10-20	10-20	10-20	10-15				60-115
Master Shipboard Data Logging & Processing	20-25	5-8	2-6	5-10	2				34-51
Towed Subsurface Instrument Package	20-30	10-15	10-20		2-10				42-85
Air-Sea Interface Environmental Data Recording	20-30	10-15	10-20		2-8			10-20[1]	52-93
Marine Seismic Receiving	20-40	10-20	5-10					2-4[2]	37-74
Underwater Television	15-20	5-15	5-15		2-8				27-68
ASWEPS SHIPS									
Shipboard Oceanographic Synoptic System	45	NA	NA	21	NA				66
SHIPS-OF-OPPORTUNITY									
Oceanographic Instrument Suit	25-100				2-5	4-8		25-50[3]	56-163

Footnotes: [1] U.S. Weather Bureau Requirements
[2] U.S. Geological Survey Requirements
[3] MSTS (Military Sea Transportation Service) & U.S. Merchant Marine

*Scientific Community refers to Scientific and educational institutions engaged in marine studies.

c) sensor electrical cable handling devices
d) monitoring and display consoles
e) accessory equipment to prepare the data for rapid, automatic, radio transmission

Design criteria must include all-weather capability and ship-to-ship portability.

Ships - Of - Opportunity will be equipped with a special "instrument suit" also to collect much needed data. These are ships that have missions other than research, such as: aircraft carriers, cruisers, destroyers, mine sweepers, subs, oilers, tankers, cargo ships, ice breakers, Merchant Marine units, Air Force ocean range vessels, etc. The operation of instrumentation for oceanographic research on these ships is not to interfere with the ship's primary mission.

The "instrument suit" must perform accurately and reliably with a minimum of maintenance on ships that are *underway*, i.e. at speeds of 0 to 18 knots (and in sea states of 0 to 5 knots). The "suit" must be so constructed as to permit transportability from one platform to another. Components of the "instrument suit" will be:

a) AN/UQN type of Sonic Sounding Set to record 0 to 6000 fathoms.
b) precision depth/graphic recorder to use with AN/UQN.
c) electronic bathythermograph with associated winch-wire-boom/recorder/readout assembly.
d) automatic recording sea-surface temperature probe.
e) meteorological suitcase (sensors: air surface temperature, barometric pressure, relative humidity, surface wind and radiation).
f) towed magnetometer with all-weather capability.
g) "interim" wave height measuring/recording device.

Modular construction should be employed throughout the system. All recording equipment should, as much as possible, be automatic, and should be compatible with the National Oceanographic Data Center for data transfer purposes.

Most important factor engineers and designers should be concerned with is environment. It must be completely understood that all the instruments and systems are intended for "at-sea" use. The environment of the ocean has many troublesome facets: wind, salt, moisture, temperature, solar radiation, shock, vibration, etc. Accuracy, reliability, economy, minimum of maintenance—these are all relative since they are products of man, but the most formidable—environment—is not. ★

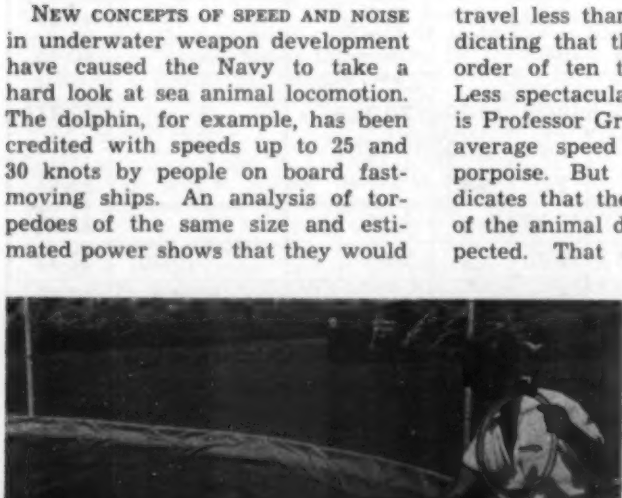
"Hello Navy. This is Notty..."

PORPOISE AIDS RESEARCH

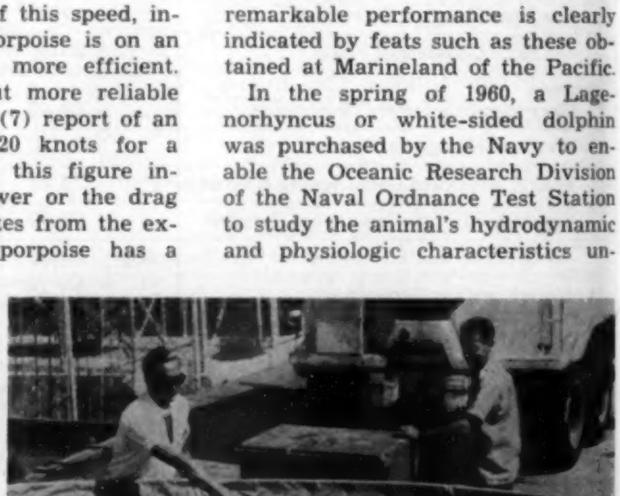
By I. Rehman, Ph.D.
U.S. Naval Ordnance Test Station, China Lake,
and University of Southern California, School of Medicine, Los Angeles

New concepts of speed and noise in underwater weapon development have caused the Navy to take a hard look at sea animal locomotion. The dolphin, for example, has been credited with speeds up to 25 and 30 knots by people on board fast-moving ships. An analysis of torpedoes of the same size and estimated power shows that they would travel less than half this speed, indicating that the porpoise is on an order of ten times more efficient. Less spectacular but more reliable is Professor Gray's (7) report of an average speed of 20 knots for a porpoise. But even this figure indicates that the power or the drag of the animal deviates from the expected. That the porpoise has a remarkable performance is clearly indicated by feats such as these obtained at Marineland of the Pacific.

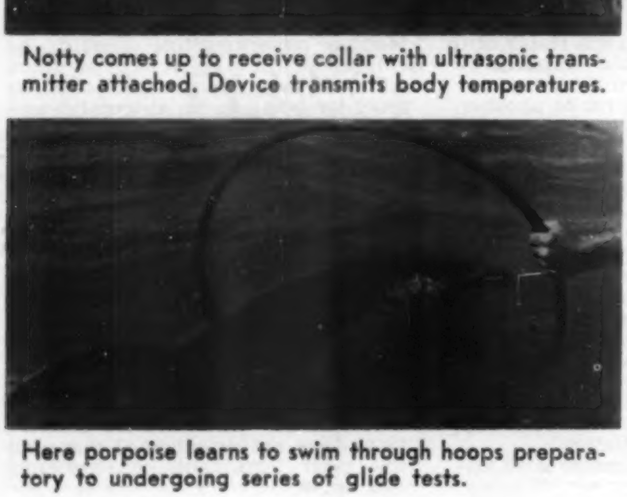
In the spring of 1960, a Lagenorhyncus or white-sided dolphin was purchased by the Navy to enable the Oceanic Research Division of the Naval Ordnance Test Station to study the animal's hydrodynamic and physiologic characteristics un-



Notty comes up to receive collar with ultrasonic transmitter attached. Device transmits body temperatures.



Notty, now instrumented with heat sensor and transmitter swims around pool in response to instructions.



Here porpoise learns to swim through hoops preparatory to undergoing series of glide tests.

In this 315-foot long tank at Convair, San Diego, precise photo measurements were made of Notty.

der controlled conditions. The porpoise, called Notty, is proving to be a remarkably alert and cooperative animal. She will don a collar and will wear it for extended periods of time. She has learned to accept the attachment of instrumentation to any part of her body, to swim through hoops and to dash off at top speed. And she is quite cooperative in making a wide variety of sounds for acoustical studies.

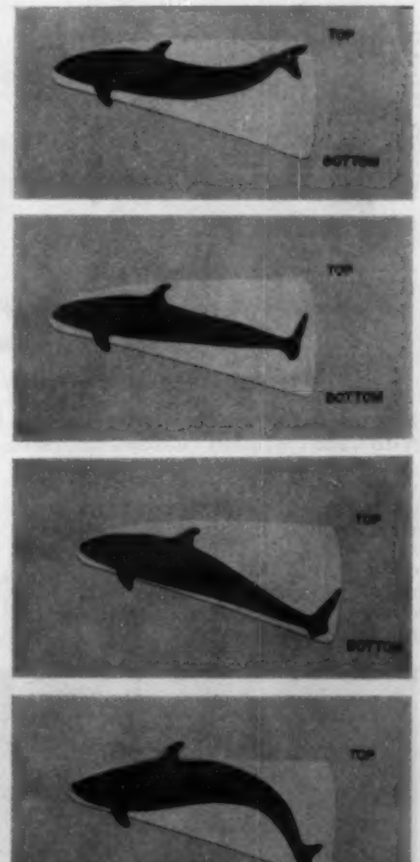
Notty learned to swim through hoops in preparation for a series of hydrodynamic tests designed to obtain accurate measurements of the animal's maximum acceleration, velocity, and glide. Additional measurements provided data on top speed, drag, and horsepower.

Test methods were established in the 24 foot glass tank in NOTS' Oceanographic Facility at China Lake. Actual performance tests were conducted in the towing tank at Convair in San Diego. This tank is 315 feet long, 12 feet wide and 6½ feet deep. Multiple cameras accurately record position versus, time.

Data on drag was obtained by using collars of varying diameters and known drag characteristics. Flow pattern information was obtained by suspending neutral density particles in the porpoise's path and by applying dye to different parts of the animal's body.

Top speed was recorded while Notty made runs without a collar as well as with collars of varying thickness. The various runs showed that the top speed without a collar was 25 feet per second or approximately 15 knots. When Notty wore a ½ inch collar, her speed was reduced to 14 feet per second. In other words, the top speed was reduced depending upon the thickness of the collar.

Drag was calculated from the de-



Note sinusoidal path of porpoise's tail fluke as animal swims normally.

BACKGROUND

THIS STUDY was undertaken by the Oceanic Division of the U. S. Naval Ordnance Test Station, China Lake and the Hydrodynamics Group of the Oceanic Division of the Research Department at the Naval Ordnance Test Station, Pasadena Annex. The cooperation of several other groups at these installations as well as that of the psycho-acoustics branch of the Navy Electronics Laboratory, Point Loma, was obtained. Additional assistance was given by Marineland of the Pacific.

Many reports have been published of sea mammals such as porpoises and whales swimming at high speeds for long periods of time with relatively small expenditures of energy. Since either the energy requirements or the drag are not as expected for these reported speeds and are beyond that available from the animal's muscular and vascular systems, accurate data and measurements under controlled conditions are needed to determine objectively whether the power output and requirements to accelerate to maximum speed, maintain top speed, decelerate, and also glide were actually being obtained.

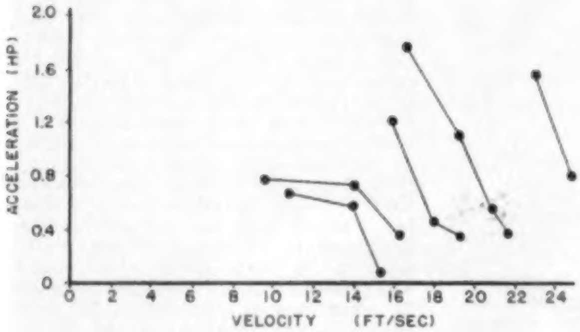
Gray[1] had calculated that the power output of a pound of whale or porpoise muscle need be no greater than that of a well-trained human. However, the requirements of the dolphin or porpoise to maintain the observed speeds required six or seven times as much power. According to this author, if the same ratio of power output of a 60-foot whale were projected to a 6-foot dolphin, the dolphin should not be able to swim faster than 9 miles per hour which is entirely too slow. Using standard human power levels and normal turbulent drag, a dolphin should swim at a speed of 15 knots and not 9 miles per hour. The assumption was also made that the form or surface of an inert whale, dolphin, or fish should have the same drag as a comparable streamlined object. This assumption, however, failed to explain the differences and led to the so-called "Gray's Paradox," i.e., (a) the speeds of large fish are greatly exaggerated, (b) the output of power from the muscles is greatly underestimated, (c), the resistance of actively swimming fish is lower than that when gliding.

In the same paper, the author makes the statement: "There seems no reason to believe that the form or surface of an inert whale, dolphin, or fish endows the body with a resistance substantially different from that of a well-streamlined object of comparable size and speed."

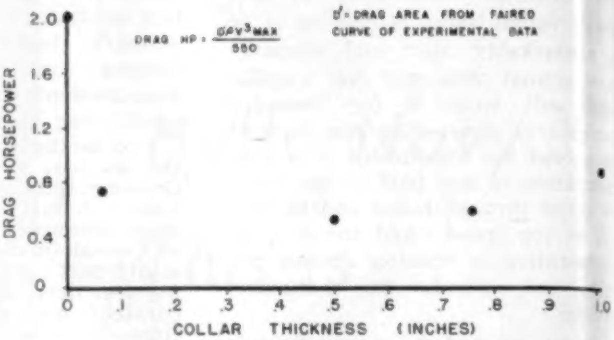
Gawn[2] also calculated the power output of sea mammals such as whales swimming at "confirmed speeds of 20 knots for 10 minutes and 14.5 knots for 2 hours." He assumed that the whales avoided turbulence and eddies by flexion of the posterior half of the body and tail and the propulsive efficiency of the tail of 75% was approximately equal to the best marine propeller. A whale developed 4.35 hp/ton at 20 knots and 1.75 hp/ton at 15 knots and therefore the whale obtains his speed by large power output rather than any special body shape or skin smoothness.

Gero[3] also calculated the power output of the porpoise in the form of thrust required for a porpoise to rise 7.0 feet out of the water to feed in 0.8 second. The thrust that the tail was required to produce was approximately 950 pounds.

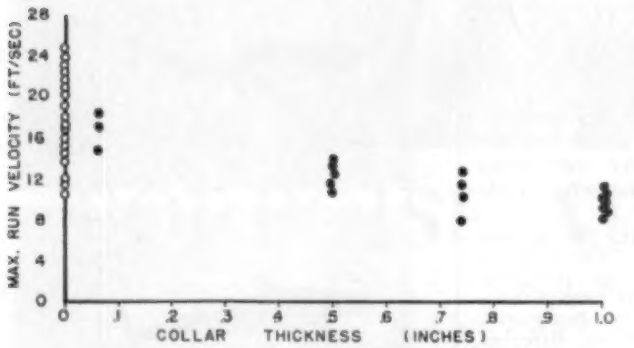
Lang and Daybell[4] in hydrodynamic tests reported power outputs in the porpoise comparable to that of well-trained athletes. These tests were carried on by the U. S. Naval Ordnance Test Station as part of a program of study of Sea Animal Propulsion and Acoustics. They found that the maximum power output was dependent upon factors such as the time and interval between tests as well as the time of day, etc. According to these authors: "It will never be known whether or not this porpoise produced its maximum effort. All that can be said is that no unusual physiological or hydrodynamic phenomena were observed in this test program." The maximum power output recorded was 2.1 hp for 0.5 second and 1.5 hp for 6 seconds. The top speed was 15 knots.



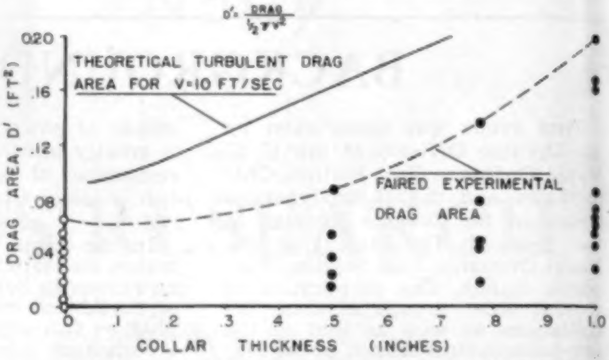
Acceleration horsepower vs. velocity



Maximum drag horsepower vs. ring thickness



Maximum velocity vs. collar thickness



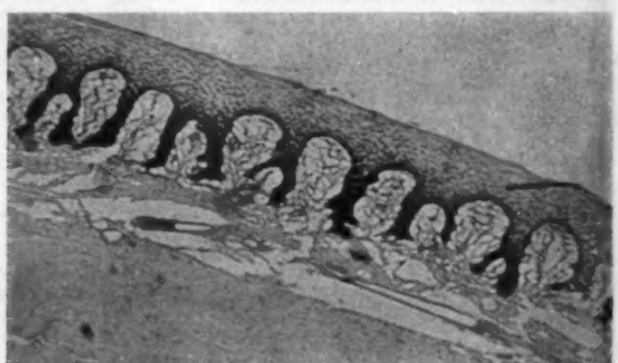
Calculated drag area vs. collar thickness

celeration rate of the porpoise both with and without collars as she glided through a series of underwater hoops. To obtain a measure of drag independent of speed, it was divided by the dynamic pressure ½ ρ V^2. This was called the drag area D'. Although Notty moved her tail in some runs, the data appeared to cluster up to a maximum value.

It was believed, therefore, that a curve through the maximum data points represented the porpoise's actual drag without movement. An estimate of the theoretical drag of the porpoise is shown by the solid line. According to this data, there is no large drag difference from the expected value.

The horsepower was calculated first by measuring acceleration. At low speeds all of the power goes into producing acceleration. As the speed increases the drag becomes greater so that at top speed all the power is expended to overcome drag.

The horsepower was also calculated by combining the top speed and the drag of the porpoise, since horsepower equals drag times velocity divided by 550. These drag



In Notty's body temperature chart notice the increase above water ambient in these areas where turbulance is most likely to occur. Researchers suspect a connection between body temperature and boundary layer control. The animal's peculiar histological structures may also contribute to drag reduction. Microscopic slides of the porpoise's skin structure in the area between eyes and snout, shows it to be relatively bloodless. Contrast this with the slide above of a skin section from the ventral surface of the flukes. Careful examination shows that dermal papilae containing the blood vessels increased in height, number, size, and complexity toward the tail end of the animal. Exact relationship of these characteristics, if any, to reduce drag is not yet known. Research continues.

horsepower calculations were made using the top recorded speed with and without collars and values of drag from the faired experimental curve. These calculations show that a maximum horsepower of 2 was obtained without a collar. With collars, the values range up to .8 horsepower.

Data from these performance tests show the drag and speed of the porpoise to be about the same as those of a torpedo of similar size and power. Although the data is considered accurate, it is possible that water turbulence, training procedures or unknown factors due to the unnatural environment produced performance results which may be considerably less than those that might be obtained from a porpoise in the open ocean.

Research often has its surprises. Notty, a Lagenorhyncus considered by authorities to be a silent animal, startled those working with her by suddenly emitting a series of loud squawks. This gave rise to the possibility of a series of controlled tests in which the origin of the acoustic pulses might be localized and the sounds recorded for analysis and classification.

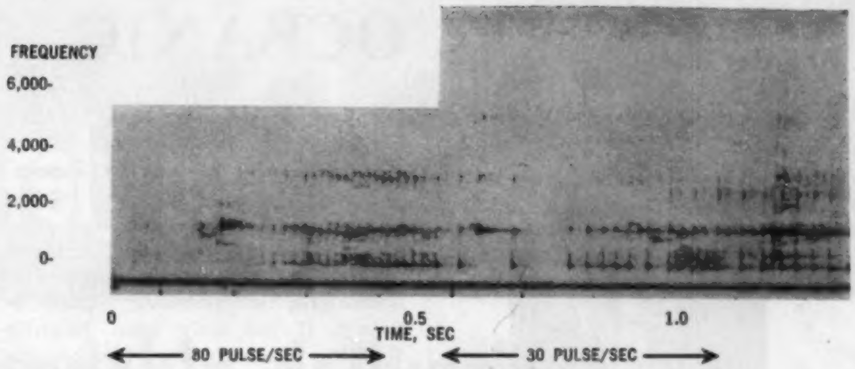
These squawking and quacking sounds usually emanate from the blow hole, however, at times no sound emanates from this source but appears to be propagated into the water when the lower portion of her head is underwater. It would appear that the animal has two methods or sources of sound propagation. Some sounds were made underwater without the emission of air bubbles.

Sonagrams illustate the various properties of the sounds emitted by Notty. This one shows two sustained quacks. Each horizontal line is a component frequency of the complex sound of the quack and they are all harmonically related.

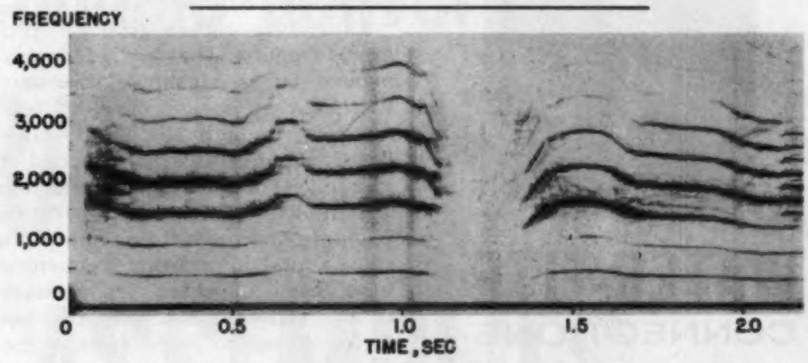
Changes in slope represent frequency modulation. Note the sudden change in frequency at about 0.6 seconds, also the dropping in frequency at the end of the quack. The second quack shows a rapid increase in frequency at the onset, and a very interesting phenomenon at 2.1 seconds, near the end. At this point the harmonic components suddenly become spaced at one-half of their previous interval. This is a one-octave drop in the fundamental pitch. Instead of eight components, we now have 16.

Another sound is a high pitched squeal or whistle which is similar to that reportedly emitted by porpoises in trouble or frightened. Note that this sound first appears at a frequency of about 16 kilocycles which was the upper limit of the analyzer. The pitch then gradually falls to about 7 kilocycles, the duration of the squeal is about 0.7 second.

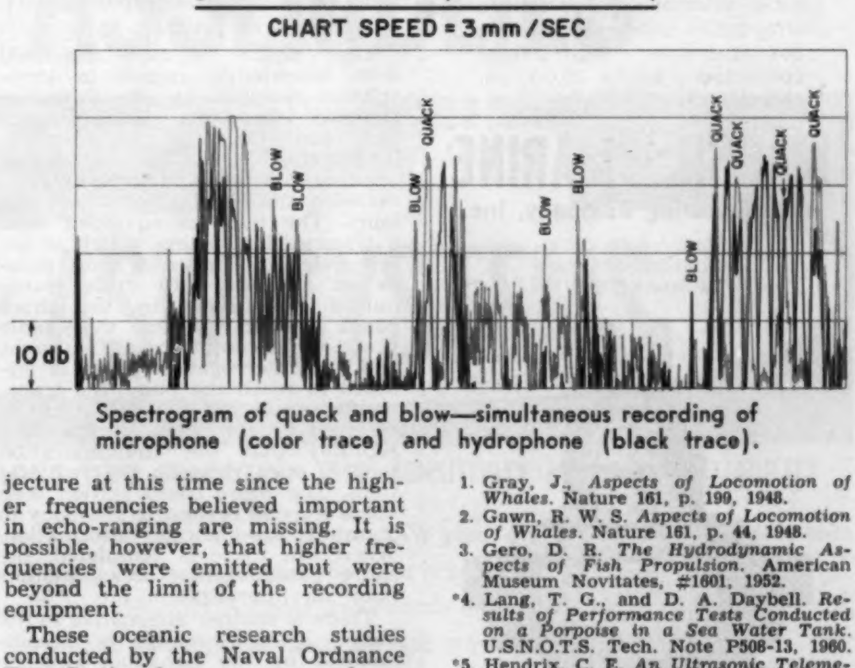
When Notty detects and homes on a piece of fish, she emits a sound somewhat like a creak and is possibly echo-ranging. All we have at this time is a recording of a series of rapidly repeated short duration pulses. The initial repetition rate is about 80 pulses per second and drops abruptly to about 30 as Notty closes on the fish. Just what this means is hard to conjecture at this time since the higher frequencies believed important in echo-ranging are missing. It is possible, however, that higher frequencies were emitted but were beyond the limit of the recording equipment.



Sonagram—echo-ranging.



Sonagram—one octave drop in fundamental pitch.



Spectrogram of quack and blow—simultaneous recording of microphone (color trace) and hydrophone (black trace).

These oceanic research studies conducted by the Naval Ordnance Test Station have a very real application in the field of anti-submarine warfare . . . specifically in the development and the improvement of underwater vehicles both hydrodynamically and acoustically.

If communications between the dolphin and man can be established and the animal's reliability determined, the animals could then be used to lead skin divers or carry mechanical equipment to underwater objects of interest; obtain photographs of underwater objects, locate mines in United States and foreign ports or in sea lanes; or even report by radio the presence and location of submarines in the open sea.★

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*5. Hendrix, C. E. *An Ultrasonic Telemeter for Physiological Measurements on Free-swimming Sea Animals*. U.S.N.O. T.S. Tech. Note 304-50, 1960.
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9. Kramer, Max. O. *The Dolphin's Secret*, ASNE. February 1961, pp. 103-107.

*Naval Publications.

This is the second in our series of articles based upon the Fifth Navy Science Symposium at Annapolis, Md.

OCEANIC TELEMETRY

by James M. Snodgrass
Scripps Institute of Oceanography

Communication, in one form or another, is inextricably linked with oceanographic research. Unfortunately, it has only been recently that the oceanographer has become aware of his needs which involve world-wide requirements.

Expanding oceanographic programs require the use of instrumented buoys capable of transmitting data by means of radio telemetering to both ship- and shore-based stations. If we must depend on frequencies in the electromagnetic communications spectrum, future planning becomes near-impossible since almost all existing frequencies have been allocated for military, commercial and amateur interests. There appear to be no suitable frequencies for extensive communication to the oceanographically-oriented research program.

The "squirt" system combined with knowledge gained in ionospheric research by the Canadian Defense Research Establishment may well prove to be valuable. Hypothetically, the method developed would involve interrogation between the shore station and the buoy. The buoy is equipped with a transponder system which is interrogated by means of short pulses on a short duty cycle transmitted repetitively by the shore based station. When the radio propagation conditions are suitable, and the interrogation pulse is enabled to reach the buoy, the transponder sends out a pulse which is received by the shore station. This signifies that the communication path is open between the two stations. The shore based station then sends a coded request to the buoy to transmit its stored information. When this cycle is completed, the shore based station seeks another buoy for interrogation, etc.

There is another alternative to the above system, which is recommended by the Canadian Defence Research Group. This is to have available a wide range of frequency bands through which the shore based system could transmit an interrogation pulse in sequence. This means the buoy would have to have a rather sophisticated receiving system—one capable of auditing all bands simultaneously. However, if such a system is used, the assurance of being able to effect communication with the remote station when desired is greatly improved.

Anticipating the general problem, the Office of Navel Research contracted with the Convair Division of General Dynamics Corp. to perform a study on oceanographic telemetry. Some of the factors involve the behavior of specific radio frequencies in regard to radio propagation characteristics, such as skip distances, solar induced radio propagation anomalies, seasonal variations of noise with respect to latitude, power requirements, frequency bandwidths, etc.

It appears that long range communication may not be reliable when using available frequencies between buoys and shore-based or ocean stations, assuming that dependable communication is required.

For the past ten years, a group has been working on the development of radio telemetering ocean buoys and instrument stations.[1] Each succeeding buoy design involved greater amounts of radiated RF power. Recent designs evolved around "squirt" techniques with power levels as high as 5 kw.

The problem of non-interference with existing services is an extremely sticky one. In a paper presented at the 1961 National Telemetry Conference (Chicago), Mr. Roy Gaul described a system installed in the Gulf of Mexico which encountered an entirely new series of headaches for the oceanographer. The area of planned installation was physically in an overlap area between the Patrick and Eglin Air Force Base Missile Ranges, and it appeared to be almost impossible to find suitable means of using radio frequencies considered acceptable by the Air Force. However, Mr. Gaul has worked out means of operation—for the present, at least. Nonetheless, the problem is again faced in the larger Atlantic and Pacific Missile Ranges and is presently without solution.

Looking first at techniques which would permit buoy operation, we have considered the possibility of systems which would permit the use of relatively low power transmitting systems in the buoys. Perhaps the most available method at present to begin to solve the buoy-shore communication problem, and evolve a method which could be put into effect with existing technical facilities, is the use of high flying aircraft to serve as an interrogation platform for communicating with floating buoys, etc. This would permit the use of relatively low power radio transmitters in the buoys and a relatively simple information storage system. The high flying plane would transmit a suitable coded interrogation pulse which would insure the response of the desired buoy. Since the airplane would be carrying a suitable recording system, such as magnetic tape, the information transmitted by the buoy

[1]Mr. E. F. Corwin, Mr. L. J. Allison, Mr. J. C. Appleby, Meteorological Branch, Bureau of Naval Weapons; Mr. Harkarinen, Electronics Branch, National Bureau of Standards.

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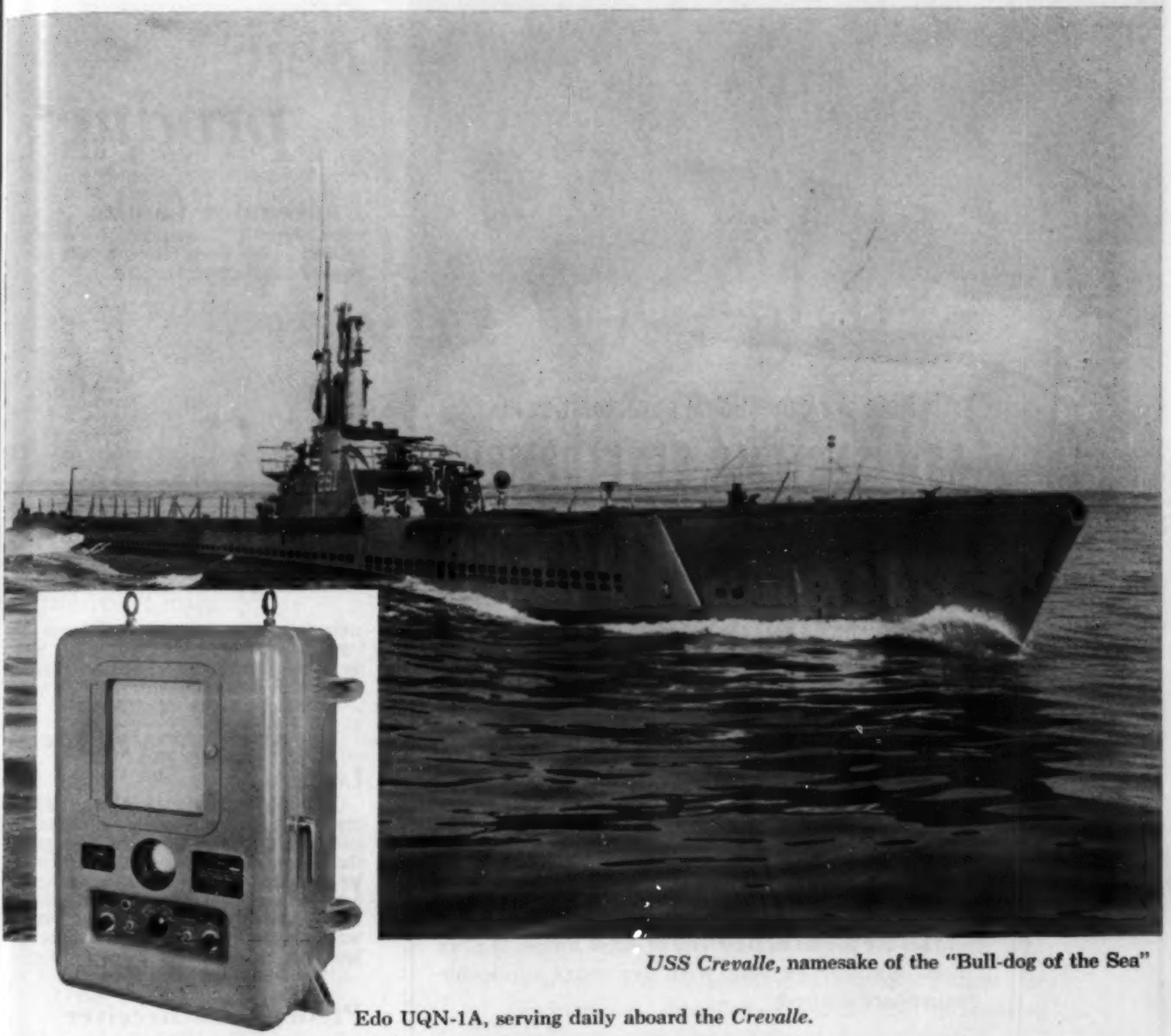
Circle Reply Card No. 18

could be recorded as desired. In this system it would be planned to have the data processed at the conclusion of the flight. Difficulties with this system are not to be minimized since it requires the availability of suitable high flying long range aircraft, as well as the necessary operating bases. However, it should be possible to carry out some fairly extensive programs with existing bases and aircraft. It should also be pointed out that suitable radio frequency assignments must be made if communications of this type are to be carried out. Unquestionably, a suitable long range aircraft for our purposes would be the U-2, which satisfies many of our basic requirements. Whether the plane would actually prove suitable for such operation, remains to be seen.

Another and most promising system for long term operation is to be found in the various types of communication satellites. The satillites which are planned for orbits between 5,000 and 6,000 miles will undoubtedly require powers not readily available to small floating buoys and instrument stations. However, these satellites can be counted upon for communicating between ships and shore bases that are capable of using stabilized antennas. This would allow data to be sent directly ashore in real time—via satellite—for data analysis as desired. This type of satellite is known as "active". Another type of satellite known as the Courier type is perhaps the most adaptable under the present basis of operation. The Courier type of satellite does not re-transmit signals in real time, but involves a relay system. It is planned on being programmed to a much lower orbit, in the range of 300 to 400 miles. Since it is lower, it will require a great deal less power to effect reliable communication between buoy and satellite.

At present, the Courier satellite is designed to record data received via radio and play it back on proper interrogation from the ground based station. It is considered practical to program the Courier type of satellite to interrogate buoys as it passes over various portions of the ocean and then to play back or reproduce the data obtained from the buoy when it passes over a suitable land based station. The land based station would be able to keep a longer contact with the satellite, since it would have a much superior antenna system than that possessed by the floating station.

A most significant problem presently exists with the proposed use of any of the satellites and this is the fact that there are now tremendous demands upon the electromagnetic communications spectrum that is expected to be available to the satellite systems, and unless the research groups interested in obtaining ocean data make a very strenuous effort to obtain proper frequency allocations, or time allocations, on the communications types of satellites, it is quite certain that none will be available when needed at some future date. It is almost impossible to overemphasize the amount of pressure being brought to bear to obtain communications frequencies in the satellite programs. ★



USS Crevalle, namesake of the "Bull-dog of the Sea"

Edo UQN-1A, serving daily aboard the *Crevalle*.

DURABLE DEFENSE TEAM...USS CREVALLE and EDO'S UQN

When the Navy's *USS Crevalle* made her 9,000th dive off New London recently, precise bottom sounding data was relayed to her Control Room crew by Edo UQN-1A, Serial #1. Here's a remarkable record of longevity, in an era noted for fast obsolescence.

The submarine *Crevalle*, commissioned 24 June 1943, made seven war patrols during World War II, sank 22 Japanese ships and damaged 10 more, earned numerous citations for ship and crew. Twice she was decommissioned, twice again re-commissioned. Now, as AGSS 291, the *Crevalle* is in constant operational readiness, also trains new submariners for fleet duty at New London, Connecticut.

Matching the *Crevalle* in durability is the UQN deep depth sounding unit in daily use in her Control Room. Edo delivered this unit to the Navy 20 October 1950. UQN-1A, Serial #1 has since been followed on Edo's production line by more than 1,200 UQN units—a quantity production record unmatched by any comparable equipment.

Edo's UQN, now in a sophisticated 1E model, is standard depth sounding equipment aboard the Navy's surface ships as well as her submarines . . . including the entire new nuclear-powered fleet.

Edo CORPORATION
College Point 56, L. I., New York

In Canada:
Edo (CANADA) LIMITED
Cornwall, Ontario

Circle Reply Card No. 19

new products

Underwater Camera

The Raymond Development Co. has announced a new device which incorporates a Polaroid Land camera. Included is a plastic

pressure-proof housing with 6 external controls. A unique film advance mechanism inside the housing rolls up the pictures allowing each picture to be displayed after it is taken.

Circle Reply Card No. 200

COMMUNICATIONS

Loran C

Collins Radio Company has announced the commercial availability of its new transistorized Loran C receiver for precision navigation. The receiver provides continuous position fixing information for land, sea and air navigation. The equipment also has applications in anti-submarine warfare, monitoring, underwater cable laying and repair, mapping and surveying, and test range instrumentation.

Circle Reply Card No. 201

Predetection Receiver

Dynatronic's new predetection receiver provides, within a single assembly, a means for collecting telemetry data for recording prior to demodulation. If output for recording may be selected at 900, 450 or 225 kc.

Circle Reply Card No. 202

Remote Control

Wireless remote control of four independent functions can be accomplished with a new ultrasonic system developed by RMS Associates, Inc. The solid state system consists of a miniature, hand-held, battery operated 40 kc transmitter and compact receiver. Control can be achieved with up to 30 ft. separation when the transmitter is powered by a long-life 22v mercury battery.

Circle Reply Card No. 203

INSTRUMENTATION

Temperature Sensor

Temperature Systems, Inc., announces the availability of a platinum immersion temperature sensor, designed and tested to meet nuclear environments of 1 (11) ergs/gram (c) gamma and 1 (15) n/cm², En > 2.9 Mev nuft nutron flux.

Circle Reply Card No. 204

Signal Conditioner

Astra Technical Instrument Corp. has announced a new line of thermocouple signal conditioning equipment. This modular, 8-chan-

nel unit accepts signals from a thermocouple reference junction and converts these—through biasing, attenuation and calibration—to a useable form for direct galvanometer monitoring.
Circle Reply Card No. 205

"Hydro Probe"

A completely self-contained hand-held sonar unit is being produced by Raymond Development Co. The unit is capable of operation to depths of 200 ft., and a meter shows distances to large objects over 100 ft. away. It can also be used as a depth finder. Internal battery will run unit for 40 hours.
Circle Reply Card No. 206

Depth Sounders

Raytheon Company has made available two new electronic navigational aids—a deep water recording depth sounder and a companion indicating depth sounder. The DE-714 indicator is a flashing light unit with a nine-inch dial depicting depths to 300 ft. The DE-715 recorder has a choice of 3 ranges, in either feet or fathoms: 0 to 300, 240 to 540, and 480 to 780. Both are designed for synchronized operation.
Circle Reply Card No. 207

Sequence Timer

A compact chronometric timer from Geodyne Corp. provides switch closures and openings ranging from once every ten minutes to once every twelve hours. A small 4.5 v. "A" battery will power the timer for 8-12 months. Accuracy is ± 10 seconds per day over a temperature range of 30° to 140°F.
Circle Reply Card No. 208

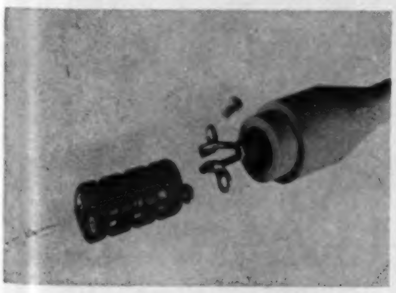
Servo

A miniature servo designed for use in both analog and digital systems has been introduced by General Precision's Librascope Division. The servo, designed for applications in airborne and shipboard navigation and fire control transformer, motor-tachometer, amplifier, shaft encoder and gear train. The unit weighs 12.5 oz. and measures 3½ in. long and 1¾ in. diam.
Circle Reply Card No. 209

HARDWARE

Repairable Plug

Vector Mfg. has introduced the first known waterproof field repairable plug, known as the "Junior". Designed to be used with signal



circuits for offshore geophysical work, seismography, and oceanography, the "Jr." plug features Vector's exclusive replaceable banana pin screw-in connection. Repairs can be made in less than 4 minutes.
Circle Reply Card No. 210

Flat Bonded Cable

Spectra-Strip Wire & Cable Corp. announces a new type of flat bonded cable in gauges from #10 to #30 AWG. Exceptional moisture resistance is claimed, making it suitable for

underwater service.

Circle Reply Card No. 211

Cable Fairing

A type 107 Cable Fairing is manufactured by Braincon Corp. to solve the widespread problem of cable noise and fatigue in towed underwater acoustic systems. Formed in 6-in. sections, the fairings yield optimum effectiveness at about 6 knots.

Circle Reply Card No. 212

POWER

AC Motor

A compact lightweight continuous duty .05 HP 400 cycle ac motor has been developed by the Hoover Electric Co. The 3 phase motor is explosion-proof constructed and weighs one pound. Dimensions are 3.02 in. and 1.74 in. in diameter.

Circle Reply Card No. 213

Rotary Actuators

The Menasco Mfg. Co. is producing a hydraulic rotary actuator which converts hydraulic pressure into mechanical torque. Operating on pressures up to 5000 psi, rotary torque output ranges from zero to 50,000 in-lbs. Angular rotation to 200° is offered with controlled and cushioned deceleration at the limits of rotation.

Circle Reply Card No. 214

Rectifier "Flats"

New space-saving selenium rectifier "flats" are available from Radio Receptor Co. in large power-handling units. The power flats utilize a unique construction that reduces forward resistance for lower IR drop—hence less heat produced for a given load.

Circle Reply Card No. 215

literature

Oceanography

The Western Gear Corp.'s most recent issue of their company publication, High Gear, features their company's capabilities in the oceanographic field.

Circle Reply Card No. 216

Resins

A revised edition of its "Maraset Electrical Resins Selector" has been issued by the Marblette Corp. The brochure is a guide to Marblette's insulating resins and their uses for potting, encapsulating and coating parts and assemblies.

Circle Reply Card No. 217

Math Handbook

A 64-page pocketsize handbook containing formulas, powers, roots, logarithms, decimal equivalents, weights and measures, conversion factors, etc. is offered by the Curta Company.

Circle Reply Card No. 218

Seawater Battery

A technical data sheet describing its new seawater battery is available from Yardney Electric Corp. The battery is a primary unit consisting of silver-chloride and magnesium duplex electrodes and is activated by the flow of seawater through it.

Circle Reply Card No. 219

Band Pass Filters

A data sheet on band pass telemetry filters designed for replacement of conventional filters in telemetering applications has been released by PCA Electronics.

Circle Reply Card No. 220

Wires and Cables

A new booklet, "Wires and Cables for Electronic Equipment and Systems", has been issued by General Electric's Wire and Cable Dept. The booklet includes complete data on multi- and single-conductor cables in a wide variety of constructions.

Circle Reply Card No. 221

Transducer

A 4-page brochure from Hydropoise, Inc. discusses a unique electrical pulse output type transducer. Applicable to any liquid or gas, the transducer will withstand pressures up to 5000 psi.

Circle Reply Card No. 222

Modularization

Control Logic, Inc., announces the release of a new brochure that describes its miniaturized products and new concepts of true modularization. These products are applicable to advanced control and data processing equipment systems.

Circle Reply Card No. 223

Products Catalog

Availability of an 86-page catalog is announced by Electron Products. Catalog includes a facilities brochure and 8 tabulated divisions covering capacitor construction with different materials. Each section covers electrical and environmental data and performance curves.

Circle Reply Card No. 224

Solid State Amplifier

Video Instruments Company, Inc. has made available a short form catalog of solid state amplifiers for instrumentation, telemetry and laboratory testing applications.

Circle Reply Card No. 225

Heel and Toe Watch

The Fiscal Year 1963 Defense Budget, among other things, will almost certainly provide funds for starting towards a 41-boat POLARIS submarine fleet. That's 12 more than the 29 now planned. Present thinking is that the 29 FBM submarines will be on patrol by the end of 1964; the 41, by the end of 1967. It's our bet that before we're through there will be 49 POLARIS subs authorized and that the whole lot will have been commissioned by 1967.

A break-through in r.f. transmission through seawater? We've picked up reports that a contract has been let to study the attenuation of radio frequency energy in the 8.5-to-10.5 kilomegacycle range through seawater. We don't know the dollars involved nor the contractor. We'd guess that Office of Naval Research is the contracting agency.

From Naval Electronics Laboratory, Pt. Loma, Calif., we hear that efforts are being made to win funding approval for a small, CO_2-powered two-man research submarine. Design is supposed to be all done. Economy and reliability are cited in its favor.

Navy's answer to Congress and its complaints that our ASW effort lacks organized management (single management as in POLARIS) is to PERT the whole ball of wax—planning, programming, procurement, contractors, etc. PERT is the hot-shot management system that helped POLARIS to its present level of achievement. This may be a boondoggle, for PERT is a management *aid* not a management *substitute.*

Letting of Mohole contract has hit a snag. Of the 84 companies attending the original r.f.q. briefing, over 10 have replied. Proposals are so complex and vary so much from one another National Science Foundation is having trouble making a decision.

A stabilized navigation system accurate to one minute of arc (one nautical mile) has been developed by Dr. W. S. von Arx at Woods Hole Oceanographic Institution. Called GEON (Gyro Erected Optical Navigation). Given local vertical (determined by gravity) and north point to define local meridian plane, system enables accurate celestial latitude and longitude fixes to be taken. Has been tried out on research vessel CHAIN.

—Captain Nemo

people

PICCARD

ENKE

Jacques Piccard, world-famous pioneer explorer of the ocean depths, has been appointed consultant to Loral Electronics Corp.'s new oceanographic activities. Piccard will work closely with Dimitri Rebikoff, internationally known underwater expert, who directs Loral's oceanographic operations.

Appointment of **Dr. Scott C. Daubin** of the marine sciences section of the Sea Operations Dept./General Motors Defense Systems Div. has been announced. Scientific laboratories are located in Santa Barbara, Calif.

Calvin A. Gongwer, one of the nation's foremost hydrodynamicists and manager of Aerojet-General's Oceanics Div., has been named Vice President, Special Projects, of the Global Marine Exploration Co. Aerojet recently purchased a 45 per cent interest of Global Marine.

Dr. Joseph F. Mount, West Coast mathematician and computer scientist, has been appointed director of Minneapolis-Honeywell's Computing and Educational Center at the Univ. of Southern Calif.

General Precision's Librascope Division announced the appointment of **George T. Mundorff** as administrative assistant to R. E. Hastings, division Vice President.

Herbert H. Hibbs has been named Antenna Laboratory Director for Aero Geo Astro Corp. His experience includes working on submarine direction finding antennas, telemetry, beacon and command antennas for the BLUE SCOUT missile programs.

Dr. Stephen Enke, professor of economics at Duke University, will organize the expansion of the Economics Division of the Operations Evaluation Group, M.I.T. The Division will be concerned with problems of logistics, weapon systems evaluation and Navy support requirements.

Henry Lawry has been appointed Project Administrator for the Vocaline Co. of America, Inc., where he will head the Sonobuoy test evaluation program now being conducted by Vocaline's Maine Labs for the Navy.

Arthur W. Galusha was appointed manager of the Northesat Regional technical Liaision office of Litton Systems, Inc., a division of Litton Industries.

Two noted Physicists have been named to research posts in Varian Associates' Instrument Division. **Dr. Harry E. Weaver** was appointed manager of optical pumping and cryogenics research; and **Dr. James T. Arnold** was named manager of research in geophysics and space physics.

Samuel E. Eastman has been named to the new post of Director of Development Planning and **William P. Murden, Jr.** succeeds him as director of the Washington Research Office of Technical Operations, Inc.

The election of **Dr. Theodore H. Maiman** as a Vice President of Quantatron, Inc. has recently been announced. Prior to joining Quantatron, Dr. Maiman worked at Hughes Aircraft where he developed the first liquid nitrogen cooled MASER, which eventually led to his invention of the first ruby LASER.

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